A. L. Warr.

ELEMENTARY
NAVAL ORDNANCE AND GUNNERY

ELEMENTARY NAVAL ORDNANCE AND GUNNERY

INCLUDING CLOSE-ORDER INFANTRY

BY

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IN CHARGE OF INSTRUCTION IN ORDNANCE AND GUNNERY AT
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WITH OVER 50 ILLUSTRATIONS FROM DRAWINGS AND PHOTOGRAPHS

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FOREWORD

In the preparation of the following pages it has been continuously the aim to present the subject in a direct, simple manner, such as to make it most readily understandable to those readers who desire to secure a sound, fundamental, and good general knowledge of the subject.

Particularly the needs of those new officers, especially of our Naval Reserve Force, who have had little or no opportunity to familiarize themselves with this subject, have been kept constantly in mind, as have also the needs of those members of the enlisted personnel who are striving for advancement and commissions.

The subject matter has been based, to a large extent, on lectures delivered to two consecutive classes of Cadets at the Ensign School at Harvard University, and thanks are due to the members of these classes for their many questions, that were the inspiration of the majority of the explanations contained herein.

Frequent reference has been made to standard naval publications, principally Naval Ordnance, Ship and Gun Drills, Landing Force and Small Arms Instructions, Bluejackets' Manual, and Naval Regulations and Instructions. Where the text may seem brief, reference should be made to these.

Special effort has been made to combine in one cover all the information on the subject most essential to young officers and others of the Service, somewhat in the manner of a handbook. All vital and essential points have been em-

phasized by the use of heavy type, for the purpose of ready reference and hasty review.

The chapter on Close-Order Infantry has been included in order to bring this important subject closer to some who might otherwise neglect it and to explain certain positions and evolutions from perhaps a somewhat new and different angle for the benefit of those new to the Service.

Thanks are due to the United States Naval Institute and to the International Text Book Company for the use of certain sketches and photographs reproduced herein.

HOBART COLE RAMSEY.

JUNE 1, 1918.

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ELEMENTARY NAVAL ORDNANCE AND GUNNERY

CHAPTER I

NAVAL GUNS

VARIOUS TYPES — DESIGNATION AS TO TYPES AND LOCATION — PRINCIPAL PARTS (INTERIOR AND EXTERIOR)

Modern naval guns are all of the breech-loading, rifled type.

Breech loading distinguishes these guns from the old muzzle-loading type of Civil and Revolutionary War days and indicates that the projectile and powder charge are both placed in through the breech or inboard end of the gun when it is loaded.

Rifled distinguishes the modern gun from the old types referred to above, in that the old guns were smooth bore, the interior of the bore being a perfectly smooth surface. The guns fired a spherical shell or projectile. In a **rifled gun** the interior of the bore is cut into a system of grooves and raised portions, or **lands** as they are properly termed. **These grooves and lands constitute the rifling in the gun.** They twist spirally through the gun bore from the powder chamber, at the breech end of the gun, to the muzzle. **When a projectile is fired, the rifling imparts to it a clockwise, rotary motion about its axis,** as it travels down the bore due to the pressure behind it, occasioned by the explosion of the powder charge. With a long, cylindrical projectile, such as is used today, this rotary motion maintains the original direction of

the projectile, point forward, after it leaves the gun, and prevents the projectile from eventually traveling end over end or **tumbling.**

VARIOUS TYPES OF NAVAL GUNS

BREECH-LOADING RIFLES, OR B. L. R.'S, as they are commonly known, are guns that are loaded with separate ammunition; that is, ammunition where the shell or projectile is entirely separate from the powder charge; the powder charge being contained in bags which are placed in the gun in rear of projectile before firing. Generally speaking, practically all modern guns from 6-inch upward, or including 16-inch calibers, at the present day, are B. L. R.'s. Many new 5-inch guns which compose the broadside batteries of some of the late dreadnoughts use fixed ammunition and are therefore not B. L. R.'s. Also, there are a few new 6-inch guns that are not B. L. R.'s.

RAPID-FIRE GUNS are also breech loading, and rifled, but are distinguished from B. L. R.'s in **that they use fixed ammunition**; that is, ammunition where the entire charge of the gun-projectile, powder, and primer is contained in a single, metal (usually brass) cartridge case. Also, the breech mechanism of a rapid-fire gun is somewhat quicker in its action than that of a B. L. R. This quick-acting breech is effected by an operating lever that opens the breech by one continuous outward movement of the arm. In the latest type of rapid-fire gun an operating lever requiring two separate movements of the arm in opening is used. The slight degree to which this breech is quicker acting than that of a B. L. R. of the same type is due to the fact that it is lighter in weight and is more easily handled.

Generally speaking, all guns from and including 1-, 3-, and 6-pounders, to 3- and 4-inch guns are of the rapid-fire type. The new 5- and 6-inch guns mentioned under B. L. R.'s are also of the rapid-fire type. There is one point of difference between these 5- and 6-inch guns and others of the rapid-fire type in that they are loaded with what is known

as **semi-fixed ammunition.** In semi-fixed ammunition the powder is contained in the metal cartridge case the same as in fixed ammunition, but the projectile is separate and is loaded separately into the gun. Semi-fixed ammunition contains the advantageous features of fixed ammunition and can be easily handled on account of the weight being divided.

SEMI-AUTOMATIC GUNS are a particular type of a rapid-fire gun. They are single-shot guns that fire fixed ammunition. The **semi-automatic feature** causes the force of the explosion from any shell fired to open the breech of the gun and eject the empty cartridge case, leaving the breech of the gun open until a new loaded cartridge can be inserted, whereupon the breech closes automatically and the gun is again ready for firing. **The only operation required by the loader is the placing in position of new cartridges.** All semi-automatic guns are either 1-pounders, 3-pounders, or 6-pounders; also there is one type of 3-inch gun in use that is semi-automatic in operation (Driggs-Seabury 3″ S. A.). **Do not be misled, however, to the idea that all 1-, 3-, and 6-pounder guns are semi-automatic in action.** There are many guns of these sizes that are only rapid-fire guns, without the semi-automatic feature.

AUTOMATIC GUNS are small-caliber guns that fire continuously as long as pressure is maintained on the trigger and the ammunition is properly fed. The ammunition consists of regular .30 caliber small-arm cartridges which are held together in a web belt or wire clip. This web or clip feeds through the breech of the gun automatically as the gun fires. Unexpended gas from the explosion of the first cartridge fired operates mechanism to eject the fired cartridge case, load a new cartridge, and fire that, the operation continuing automatically and successively as long as pressure is maintained on the trigger. The Colt Automatic, the Benet-Mercie and the Lewis Automatic guns are in this class and are the ones principally used in the U. S. Navy.

MACHINE GUNS are also small-caliber guns using for ammunition regular .30 caliber small-arm cartridges. **These**

guns differ from automatic guns in that the mechanism must be operated by some outside power, such as a small motor or the turning of a crank, usually the latter. While the crank is turned and the ammunition is properly fed the cartridges are loaded, fired, and the shells ejected continuously and successively. These guns serve practically the same purpose as automatic guns. The principal use of either gun is on landing parties ashore, and mounted in small boats. On battleship quarterdecks there is usually a place aft for these guns to be mounted for emergency use.

FIELD GUNS, as may be inferred from the name, are guns for use in connection with landing parties. They are always of 3″ caliber and are mounted on wheeled gun carriages.

DESIGNATION OF GUNS AS TO TYPE AND LOCATION

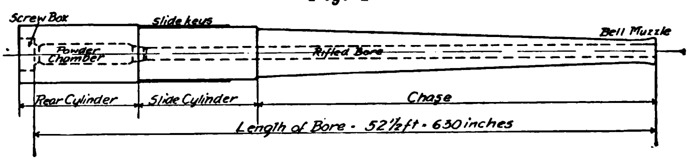
All guns above 3-inch caliber are designated: **first, by the diameter of the bore of the gun in inches**; **second, by the length of the gun in calibers**; **third, by the type of gun, such as B. L. R., Rapid-fire Gun, etc.**; and **fourth** by the **Mark** and **Modification** numbers, indicating whether the design of the gun is of the latest or of several years back.

THE DIAMETER OF THE BORE can be measured across the muzzle and from the tops of the lands of the rifling on opposite sides of the bore. It may also be expressed as the diameter of a cylinder which touches the tops of all the lands. The diameter of the bore is practically the same as that of the shell fired, allowing for a small clearance between them. It is the most important designation of guns from 3-inch to 16-inch. **This measurement is called the CALIBER OF THE GUN**; *i.e.*, in the case of a turret gun, the diameter of the bore of which measures 12 inches, it would be a 12-inch caliber gun. A Springfield rifle firing a shell .30 of an inch in diameter is called a .30 caliber rifle. (See Fig. 2, Page 10.)

The **LENGTH OF A GUN is measured in calibers from end to end**; that is, from the screw-box at the breech end

to the muzzle face. **The caliber of the gun in inches or parts of a foot is divided into the length of the gun in feet. The result is expressed as the length of the gun in calibers.** A 12-inch gun, 50 feet long, is expressed as a 12-inch, 50-caliber gun, inasmuch as 12 inches, the caliber, is contained 50 times in 50 feet, the length. Therefore the gun is 50 times the caliber in length or 50 calibers long. In the same way a 6-inch gun, 25 feet long, is called a 6-inch, 50-caliber gun, and a 6-inch gun, $22\frac{1}{2}$ feet long, a 6-inch, 45-caliber gun. The majority of guns in use in the U. S. Navy are in the vicinity of 45 to 50 calibers in length.

Fig. 1



$$\textit{Designated 45-Caliber Gun} = \frac{\textit{Length of Bore}}{\textit{Diameter of Bore}} = \frac{\textit{630 inches}}{\textit{14 inches}} = \textit{45 Calibers}$$

MAJOR CALIBER (14-INCH) BREECH-LOADING RIFLE — EXTERIOR VIEW

The **MARK** and **MODIFICATION NUMBERS of a gun indicate the character of its design.** When a gun of an entirely new design is manufactured, such as the first 14-inch gun designed for our Navy, it is called **Mark I.** If thereafter a slight change in the design is made and later guns are manufactured according to the slightly modified design, this changes the **Modification** number, so that the gun is then designated **Mark I, Mod. I.** Another slight change in design would make the gun **Mark I, Mod. II.** If now a radical change in the design is made, it changes the Mark number; *i.e.*, **Mark II.**

It may be simply expressed that a change in the Mark number of a gun follows a radical change in its design; a change in the Modification number follows a slight change in the design. Any change in the Mark number discards all

Modification numbers, such as Mark I, Mod. IV radically changed would be Mark I. **Guns are usually marked on the breech face.** The particular Ordnance Department number of the gun itself follows the Mark and Mod. number, together with the place and year of manufacture and weight of gun. Every gun of the same design bears the same Mark and Modification number.

NOTE: Every piece of Ordnance material is marked separately and individually; *i.e.*, gun barrel; mount; breech mechanism, etc.

Summing up the foregoing on the designation of guns, a 12-inch turret gun of fairly modern construction and 45 feet in length would be designated a "12-inch, 45-caliber B. L. R., Mark VIII Mod. II." A new 14-inch gun 52½ feet in length is designated a "14 inch, 45 caliber B. L. R. Mark I."

In the case of guns under three-inch caliber they are first designated by **the weight of the projectile fired**; that is, the weight of the shell that issues from the muzzle and does not include the weight of the powder charge or cartridge case. These guns are designated as 6, 3, and 1-pounders. A gun acting semi-automatically and firing a shell weighing six pounds would be designated a 6-pounder semi-automatic rapid-fire gun.

CLASSIFICATION OF GUNS ACCORDING TO SIZE AND LOCATION

THE MAIN BATTERY is composed of all the turret guns on a ship; turret guns comprising all those of 8-inch caliber up to and including 16-inch caliber. All guns mounted in turrets.

THE INTERMEDIATE BATTERY is composed of all of the broadside guns of a ship, comprising those of 4-inch caliber up to and including those of 7-inch caliber. They are located along each side of the ship, outboard and between decks. They run from well forward all the way aft.

THE SECONDARY BATTERY is composed of all the minor caliber guns on the ship and includes 1, 3, and 6-

pounders and 3-inch guns. It does not include small arms or field pieces; only those guns that are bolted or secured to the ship's structure are in this class.

It is rapidly becoming a custom to divide the guns of a ship into two classes: the **main battery,** being composed of all the turret guns of a ship, and the **torpedo defense battery,** being composed of all guns on a ship's broadside.

On dreadnoughts the battery consists essentially of guns of only two sizes — large-caliber guns in turrets, and five-inch guns on broadsides; the five-inch guns are designated as the torpedo-defense battery although turret guns are, if necessary, manned for torpedo-defense purposes. The arrangement of the guns in this way permits much more efficient handling of the battery and makes spotting of shots much more accurate.

PRINCIPAL PARTS OF GUNS (EXTERIOR AND INTERIOR)

(See Fig. 3, Page 12)

Practically all guns used in the United States Navy are of the built-up type; that is, the guns are composed of a number of hoops or parts, separately constructed, and usually made of nickel steel. The hoops are of various thicknesses and lengths, and when assembled, the exterior parts are first heated and expanded, and then **shrunk** on over the interior parts. **The gun is "built-up" with a view to getting an assemblage of parts best able to resist the pressure of the powder gases.** For this same reason the breech end of a gun is its part of largest diameter, gradually decreasing as the muzzle is approached, the pressure of the gases from the powder being greater at the breech and decreasing gradually toward the muzzle.

In distinction from the **built-up** gun, we have the **wire-wound** gun, where wire is wound in various layers around an inner tube of steel. This makes a good gun but is expensive to construct. Also a cast steel gun in one casting, used in some foreign navies. Neither type is used in our Navy.

The inner hoop or tube of a gun, extending over practically its entire length, is called the A TUBE.

All other hoops of a gun are shrunk on over the **A Tube,** this being the basis or origin of the gun — the part on which the gun is built up.

The B_1 **HOOP OR JACKET** is shrunk on over the breech end of the A Tube and extends, as a rule, well forward on it toward the muzzle.

All hoops in the second layer, or those shrunk on right over the A Tube, are **B Hoops,** numbered B_1, B_2, etc., the numbers starting at the breech and increasing toward the muzzle.

Hoops in the third layer, or those shrunk on over **B Hoops,** are **C Hoops,** and over **C Hoops** are **D Hoops,** etc. These are numbered C_1, C_2, C_3, etc., and D_1, D_2, etc., the numbers starting at the breech end and increasing toward the muzzle in each case.

Hoops shrunk on over the B_1 Hoop or **Jacket** are also designated in general terms **Jacket Hoops,** and hoops shrunk on over the forward part or slope of the gun are similarly designated **Chase Hoops.**

Locking Hoops are very short hoops or rings covering a joint between two adjacent large hoops on the exterior of the gun, where such a joint would otherwise be exposed.

With the gun assembled we have the following EXTERIOR PARTS: (See Fig. 1, Page 5.)

The **MUZZLE,** which is the end or face outboard and the point from which the shell is ejected from the gun.

The **BREECH,** which is the rear or inboard end of the gun. It is at the breech that the gun crew stands and where the gun is loaded.

BORE OF A GUN is the hole extending from the breech face to the muzzle face. It is the cylindrical hole in the direction of the length and axis of the gun and is the path of the projectile in leaving the gun. In modern breech-loading guns, where the breech plug sets or closes into a screw-box inside the gun at the breech, the bore actually extends from the end of the screw-box, or the rear face of the gun tube, to the muzzle.

RIFLING in a gun is, as has been explained before, a system of spiral grooves cut clockwise into the interior surface of the bore or gun tube (A Tube). The raised portions between the **grooves** are called **lands.** Modern rifling in guns has an **increasing twist** from breech end to muzzle; that is, the **pitch** of the rifling gradually increases as the muzzle is approached, so that at the muzzle the maximum twist is attained. This twist is about one complete turn or revolution of the projectile in twenty-five calibers' length. Guns are in use in the U. S. Navy where the rifling has a constant pitch or uniform twist throughout the length of the bore, but no more guns of this type are being constructed, the increasing twist having distinct advantages. Particularly there is less strain on the rifling with the increasing twist.

Rifling has as its object the rotation or spinning of the shell about its geometrical axis as it leaves the muzzle of the gun. Using present-day oblong projectiles, it is essential that the point should be continually foremost while the projectile is in flight in the air. **Were it not for the rotary motion imparted by the rifling the shell would eventually tumble, or travel end over end.** It is seen, therefore, that rifling in a gun, and rotary motion in a projectile, together with its onward movement or translation, accomplish range, accuracy, and penetration of the projectile.

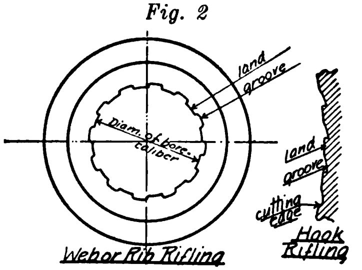
The shell itself receives its rotary motion by means of a **rotating band** or **forcing band** attached to the projectile, near its base. This band is made of copper and its **diameter is equal to the diameter of the bore of the gun at the base of the grooves of the rifling.** As the projectile travels down the bore, propelled by the force of the gases from the powder charge, the lands of the rifling cut into the soft copper " forcing band ", causing the projectile to turn in the bore and to revolve in the air to the right or clockwise after leaving the muzzle.

In the rifling the width of the grooves averages about twice the width of the lands. There are two particular types of rifling known as " **hook** " and " **web** " **rifling.** In web rifling the lands are merely raised portions of uniform width. In

hook rifling the left side of each land has a sharp edge which cuts into the forcing band. Rifling in broadside and turret guns varies between .05 and .10 of an inch in depth.

The **rotating band** will be discussed again under the heading of "Projectiles." The following points should, however, be brought up at this time. The band is securely fixed or attached to the projectile around its circumference about one inch from its base, being hammered and forced into a deep undercut score on the projectile. It sometimes occurs that a rotating band flies off when the projectile leaves the gun, but this is infrequent. The copper chips cut from the rotating band by the lands of the rifling fall into small grooves running parallel around the circumference of the band. The width of the band is one quarter the caliber of the projectile to which attached. As the projectile travels down the gun bore, gases are prevented from getting in front of the projectile by the tight joint formed between the rifling lands and the rotating band.

Fig. 2



Muzzle Face — Small Caliber Gun Showing Rifling

The **CYLINDER of a gun, or the body, as it is sometimes termed, is that part, usually of even diameter, at the breech end.** It is also that part where the metal is thickest, and it is situated over the powder chamber and screw-box, and in high-power guns, over a portion of the rifled bore, surrounding these parts. **In all guns of late types the cylinder described above is called the REAR CYLINDER,** and another cylinder forward of it, smaller in diameter, but also of even diameter throughout its length, is called the **SLIDE CYLINDER. It is this latter cylinder that fits into the slide of the gun mount.** On top and bottom of the slide cylinder raised keys are cut on the outside surface of the gun hoop. These keys fit into keyways or slots in the interior surface of the slide of the

mount. When the gun recoils after firing, the keys operate in the keyways and guide the gun back in its recoil. **The keys also prevent any rotation of the gun barrel in its mount.** The slide cylinder usually surrounds the forward part of the powder chamber and the after part of the rifled bore of the gun.

The **CHASE** of a gun is the sloping portion forward of the cylinder, or of the slide cylinder, and extending all the way to the muzzle. **It is always the chase whether in one long taper from the cylinder to the muzzle, or in stepped tapers,** such as occurs in some guns of older types and is caused by the manner of arrangement of the hoops.

A **BELL MUZZLE** is a small curved portion of increased diameter at the muzzle of the gun and at the end of the chase. At this point the metal is increased to give greater strength and to prevent enlargement of the bore as might be caused by the high muzzle velocity of a shell when it is ejected and the consequent high pressure of the gases at the muzzle. The bell muzzle is formed by cutting the required curve on the end of the hoop located at that part of the gun and is done in a large lathe, when the gun is being finished externally.

TRUNNIONS are lugs projecting one from each side of a gun at right angles to its axis and at or near its center of gravity. **They serve the purpose of supporting a gun in its carriage.** On our older type, built-up guns (of the non-recoil type where trunnions are still used), they are carried on a band or collar which is secured to the gun, being shrunk on around the cylinder.

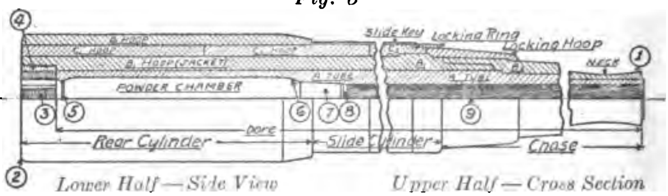
At the present date, no gun in the U. S. Navy over six inches in caliber has trunnions, and there are very few guns of any size so fitted.

Our guns are all now made **without trunnions**, the gun being supported or carried in a slide, within which it recoils. This slide is fitted with trunnions which project from it one on each side. These slide trunnions rest in seats in the carriage of the gun; the slide and the gun inside it being supported on them.

Dealing now with the INTERIOR PARTS of the gun we have the following:

The **SCREW-BOX.** — This has been referred to before, and consists of a threaded cylindrical hole opening from the breech face. This screw-box receives the breech plug and makes with it an effectual barrier at the breech to the passage of any gases to the rear when the gun is fired. The threads of the screw-box are, as a rule, cut into the interior surface

Fig. 3



BREECH-LOADING RIFLE — MAJOR CALIBER — EXTERIOR AND INTERIOR PARTS

1, Bell muzzle; 2, Breech end of gun; 3, Screw-box for breech plug; 4, Screw-box liner — threaded in jacket; 5, Gas-check seat and slope; 6, Compression slope; 7, Shell-centering slope; 8, Band seat; 9, Rifled bore.

of the rear end of the B_1 Hoop or Jacket, this hoop extending to the rear over the A Tube for the purpose. In the newer guns a **screw-box liner** is first screwed into even threads cut into the interior of the projecting end of the jacket. **The interior of this liner is then threaded to receive the breech plug.** The theory is that additional strength is added by the screw-box liner, and if the threads of the plug should become unduly burred or marred, a new liner can be easily inserted.

The **GAS-CHECK SEAT.** — This is situated just forward of the screw-box and in the after part of the gun chamber. It is a narrow section or ridge of smaller diameter than the rest of the after section of the chamber and is so shaped as to receive snugly the mushroom head of the gas-check device which is attached to and forms part of the breech plug, forming with it a tight joint to resist the pressure of gases toward the breech.

The **CHAMBER is the seat of the powder charge,** inside the gun. **It extends from the screw-box to the origin of the rifling.** It is at the rear or breech end of the bore of the gun and is of considerably larger diameter than the rest of the bore. This increased diameter gives the cubical content or volume sufficient to permit the taking of the proper charge or amount of powder and to bring about its proper ignition and explosion without utilizing too much of the length of the gun for the purpose.

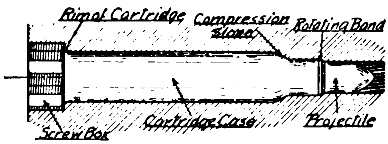
In rapid-fire guns using a metallic cartridge case or fixed ammunition, the section which receives the cartridge is likewise called the chamber.

The **COMPRESSION SLOPE** is the comparatively small section of decreasing diameter at the forward or muzzle end of the powder chamber, where the diameter of the chamber decreases or slopes down to meet the rifled bore. This slope derives its name from the fact that the gases from the explosion of the powder charge in the chamber are compressed by the gradually limited space and have accordingly greater pressure to exert on the base of the projectile as they approach it. **This is sometimes called the "chamber front slope" instead of the compression slope.**

The **BAND SEAT** and the **ORIGIN OF THE RIFLING** are found where the bore of the gun assumes its uniform diameter or the diameter of its caliber. The **band seat** is that place where the "forcing or rotating band" of the projectile rests when the projectile is seated in the gun, and the gun is ready for firing. The band seat is not in the nature of a recess or groove in the chamber. It is merely a small cylindrical section butting up against the rifling and is of the same diameter as the bottoms of the grooves of the rifling. The **origin of rifling** is just forward of the band seat and is that point where the lands of the rifling project up from the bore. At the origin or beginning of the rifling the lands taper gradually up to their full depth from the band seat. This is necessary to relieve the strain as the shell begins to travel down the gun bore and the lands of the rifling first cut into the rotating band of the projectile.

The **SHELL-CENTERING SLOPE** is a small section of the powder chamber of decreasing diameter between the forward end of the compression slope and the band seat. Its slope is less steep than that of the compression slope. Its purpose is to facilitate the proper and rapid loading of the projectile, centering it toward the origin of the rifling.

Fig. 4



Rapid-Fire Gun — Breech End Showing Cartridge Loaded in Chamber

The **interior parts just described apply in particular to a Breech-Loading Rifle using separate ammunition.** In a **Rapid-Fire Gun,** using fixed, cartridge case ammunition, there **is no gas-check seat,** the cartridge case forming its own gas check in these guns; **neither is there a shell-centering slope,** there being no necessity for it in this type of **gun.** The points of similarity are the screw-box, the band seat, the origin of rifling, and the powder chamber, this last part extending from the screw-box to the origin of rifling and conforming in shape to the cartridge case. The **exterior parts** of the Rapid-Fire Gun are the same as have been described.

In all of the foregoing description of the parts of a gun, the gun barrel has been the only major part covered. In addition to the gun barrel we have the gun mount, with its various parts including the slide and carriage; the elevating and training gear; sights; breech-mechanisms, etc. Each of these will be covered in due course.

Chapter II

MANUFACTURE OF NAVAL GUNS

GENERAL DESCRIPTION OF MANUFACTURE AND PRINCIPLE OF CONSTRUCTION

All naval guns are of what is known as the built-up type; that is, they are constructed by the assemblage by shrinking of various parts or hoops, one over the other. The theory, as will be discussed fully later on, is that this type of construction gives greater strength and elasticity and enables better resistance to the pressure caused by the explosion of a powder charge in a gun than any other type of construction.

METAL

Naval guns are made of a high quality of forged steel, containing a small percentage, from $2\frac{1}{2}$ to 3%, of nickel to give increased toughness and elasticity.

The same degree of strength is not required of the gun mounts as of the gun itself, so we find the parts of the mount made of **cast steel.**

Steel itself is of various properties and characteristics, depending largely on the percentage it contains of each of the several ingredients which, in addition to the iron, make up the metal; namely, carbon, sulphur, phosphorus, and silicon. The last three named are impurities and should be present in as small quantities as possible. The greater the amount of **carbon** present, the harder and more brittle the metal.

The quantity of impurities present in steel is regulated largely by the processes of manufacture, of which there are

several, and each of which produces good steel, dependent altogether on the purpose for which it is intended.

In United States Navy Ordnance manufacture **cast steel is produced by what is known as the Open-Hearth process.** There are two methods of producing steel by the Open-Hearth process called the **Acid system** and the **Basic system.** It will suffice to say that for our purpose the **Acid Open-Hearth** process is used and that the method pursued is briefly as follows:

A high quality of scrap steel, wrought iron, etc., containing a very small quantity of impurities is placed in a smelting furnace, wherein the metal is exposed to the direct action of a flame, which by oxidation during the melting down of the scrap removes a percentage of the comparatively few impurities present.

With the scrap there is mixed from 2½ to 3% of **nickel.** This is melted down with it and gives to the product increased toughness and elasticity. Hence the term **nickel steel.** It can easily be seen that by this process a very fine quality of steel is obtained. An excellent feature of the process is that with it, it is possible to produce large quantities of metal at one mixing.

PROCESS OF MANUFACTURE

From the **Open-Hearth** furnace, where it was kept from ten to twenty hours, the molten metal is poured into large molds to cool and harden.

Modern practice calls for the molten metal, while cooling in the molds, to be subjected to **Fluid Compression**; that is, the metal, while still molten or in fluid form in the mold, is subjected to a steadily increasing pressure up to 2300 pounds per square inch, which pressure is held for four or five hours until the metal is hard. **This process, by freeing the metal of its gas content, reduces blowholes (air holes) and imperfections.** After having hardened in the mold, the mold is removed and the metal is now called an **Ingot.**

Ingots are usually long and cylindrical in shape, approximating the shape of the hoop for which intended. On re-

moval from the mold every ingot is stamped with an identification number which it retains until it is a part of a finished gun.

During the foregoing process **various tests** were made, chemically on samples of molten metal, and physically on sections of a finished ingot.

The ingot is now taken to an **ANNEALING FURNACE**, where it is kept for about five hours at a uniform temperature of 1400° F. It is then permitted to cool slowly, taking sometimes from three to four days for a large ingot. **Annealing reduces the ingot to a soft, easily workable condition and gives an even quality to the metal.**

MACHINE SHOP TRIMMING. — After annealing, the ingot is sent to the machine shop, where it is slung in a large lathe and the ends trimmed; specified amounts of discard from top and bottom of ingot being removed.

If the ingot is to be forged hollow, it is bored roughly while in the machine shop.

FORGING. — From the machine shop the ingots go to the forge. **Forging compresses the molecules of the metal and greatly increases the toughness and strength.**

Pieces or tubes whose interior finished dimensions are small are forged solid; others are bored before forging; being forged over a mandrel, which is merely a tool entered inside the tube to support it during the forging and preserve the inside dimensions of the tube.

In the forging process the ingots are first heated to a high heat in a gas furnace, the temperature usually being 2100° F.

While at this heat, they are forged down and worked under a heavy hydraulic forging press until the desired properties have been imparted. Gun hoops are usually heated several times, all forging being done between the temperatures of 2100° F. and 1500° F.

SECOND ANNEALING. — From the forge the hoops are again annealed, this time at a high temperature and for a considerable time, to remove strains set up during forging.

MACHINING. — After annealing, the hoops are again sent to the machine shop, where rough ends are cut off and a rough

cut taken from the outside; also the interior is rough bored to within one inch of final diameter.

TEMPERING. — Gun hoops and tubes are now lowered, end down, into pit furnaces, where they are heated to a high heat and kept in this heat for from ten to twelve hours. **From the heating pit a tube is carried by a crane and immersed immediately in an oil well or bath,** the oil being cold or only slightly warm. The tube is kept immersed for from ten to twelve minutes, when it is removed. **It has now been tempered and the metal has greater elasticity. It has, however, taken on a certain brittleness, which must be removed and is removed by a short, further annealing.**

TESTING. — Each tube or hoop is now submitted to various physical tests for tensile strength, toughness, etc., as a final determination of the quality of the metal.

From the STEEL WORKS where all of the foregoing operations were conducted, the now designated **gun tube or gun hoop forgings are sent to the GUN FACTORY,** where they are finished and assembled to make complete guns.

The various steps in the gun factory are briefly outlined.

EXAMINATION FOR DEFECTS. — Upon receipt at the factory, gun forgings are again carefully inspected for defects, trueness, etc., before they are accepted.

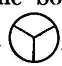
SETTING UP IN LATHE AND TURNING. — Forgings are immediately **set up and centered in a large lathe** and a rough cut turned from the outside, the aim being to **true the forging on its centers.**

BORING. — Still in the lathe, forgings are bored to final internal diameters, exceptional care being taken to insure the forgings being bored true. Four cuts are usually taken, two rough and two fine cuts to finish a bore.

BALANCE ROD. — A device used to determine whether or not a forging has been bored true. Used frequently during **boring** operation.

BORE-SEARCHING. — Every forging, when finish bored, is bore-searched, and **all bore-searching is done by officers.** It consists of a small mirror, inclined at an angle of 45 degrees

and supported on the end of a long wooden rod, being pushed through the bore of the gun. Electric lights are also mounted at the mirror and these illumine the bore, and any defects, such as cracks, blowholes, etc., are reflected in the mirror. **Bore-searching is searching the bore for any defects.**

STAR–GAUGE is an instrument used to measure the bore. Inasmuch as the bore must be accurate to one thousandth of an inch after final boring, it is necessary that means be provided to take the measurement of every part of it exactly. The star-gauge consists of three spring rods or arms 120 degrees apart, mounted on a long rod and connecting to a scale centered in the rod. As the arms are pushed through the bore, they operate on their springs to rest on the surface of the bore at all times. Thus, any variation in the diameter of the bore is communicated instantly, via the spring arms, to the scale located in the handle of the gauge in the hand of the operator. The term **star-gauge** comes from the fact that the gauge is pushed through the bore twice; the first time the arms are set in this fashion , and the second time are reversed . Combining the two shows the measurements to have been taken in the form of a six-point star .

ASSEMBLAGE OF GUN HOOPS

The **gun jacket or B_1 Hoop** is the first casting prepared in the shop as outlined in the foregoing. The B_2 Hoop is next worked on, being treated in the same manner as the jacket. Both of these hoops are now ready for assembling, **having been bored accurately to final dimensions inside, and turned down roughly outside.**

The gun tube or inner lining of the gun is now worked on. This tube is bored accurately to final internal dimensions, bore-searched and star-gauged as was the B_1 jacket; **and also the exterior of the tube is turned down to final external dimensions.**

SHRINKAGE was allowed for in turning down the exterior of the gun tube and in boring to final internal dimensions the

B_1 hoop or jacket, the figures for shrinkage having been previously computed and prescribed by the Bureau of Ordnance. Different layers of the gun have different shrinkages.

THE SHRINKING PIT. — The first step in the assemblage of the hoops is the **shrinking of the B_1 Hoop or Jacket over the breech end of the gun tube.** These parts have already been prepared in the shop. **The gun tube is now placed breech end down in the shrinking pit,** which is a well of square section sunk in the ground and equipped with two movable tables. The **breech end of the tube** at the bottom of the pit is fitted over a heavy mandrel on the lower table, the mandrel projecting up inside the tube and holding it vertically. In the upper table there is a hole through which the tube extends. If necessary, the tube may be additionally supported by screws surrounding this opening in the upper table, except during the time that the jacket is being actually lowered down over the tube, when such screws would interfere.

HEATING FURNACE. — Cold, the exterior of the gun tube is larger in diameter, by a predetermined amount, than the interior of the jacket, which must go over it. This predetermined amount is given by the Shrinkage Tables which have already been mentioned. The tube is lowered cold in the shrinking pit. The **jacket must be expanded by heat to go over the gun tube.** The jacket is therefore lowered from an overhead crane, breech end down, into **a hot-air heating furnace.** The heating is slow and regular and no warping occurs. A large jacket is kept in this furnace for about 30 hours. The temperature at the end of this time, in the case of a jacket for a fourteen-inch gun, is 725° F. at the breech end and 825° F. at the muzzle end. **The temperature at the breech end is lower to insure this end gripping first on the outside of the tube.**

FIRST ASSEMBLAGE OF PARTS. — When the jacket has received the desired expansion, it is hoisted out of the furnace, the inside diameter is measured, and if correct, the bore is wiped out with a moist sponge. The jacket is swung over the tube, which is in the shrinking pit, and is centered by men with asbestos gloves. **It is then lowered from the**

SHRINKING PIT

Showing B_1, hoop or jacket (hot) being lowered over "A_1" tube (cold)

ASSEMBLING THE GUN

Lowering partially assembled gun back into shrinking pit preparatory to shrinking on outer layer of hoops

crane, end down over the tube until it brings up at the proper point. It is guided down by workmen and twisted to prevent sticking. When it is in place, a cold spray from a perforated pipe in the shrinking pit is turned on the part which it is desired to have grip first — in this case the breech end. Water is in the meantime circulated inside the gun tube to keep it cool. When the breech end is considered cooled enough to grip, other sprays are turned on, at intervals of one minute, and are hoisted slowly up the jacket, spraying water and cooling it, so that when they reach the top, the whole jacket has gripped the tube. It is then permitted to finish cooling gradually.

The B_2 Hoop was machined for assembling at the same time as the jacket. This hoop is now heated and shrunk on over the tube in the same layer as the jacket, but over the muzzle end of the tube, the procedure being the same as in the case of the jacket or B_1 hoop.

The gun, after cooling, is now removed from the pit. It is measured and the bore is star-gauged. The exterior of the gun as now assembled (the B_1 and B_2 Hoops) is machined to required external dimensions, the gun being centered in a large lathe for the purpose.

SUCCESSIVE ASSEMBLAGES. — Each hoop is prepared for assembling in the same manner as the B_1 and B_2 Hoops were prepared, and is successively lowered over the gun in the shrinking pit and shrunk on. After the shrinking on of each hoop or layer of hoops, the gun, as then assembled, is removed from the pit, centered in a lathe, and turned down externally preparatory to receiving the next hoop or layer of hoops.

After the final assemblage, the bore of the gun is star-gauged and the compression of the gun tube due to the shrinking on of the hoops around it is checked or measured.

The gun is now ready for final machining, rifling, etc.

COMPLETION OF GUN

The assembled gun is carefully centered in a lathe and tested for trueness or spring.

The gun is now **FINISH BORED.** Great care is necessary to get the bore exactly true **and** correct **in** size to one thousandth of an inch.

CHAMBERING. — While the gun is in the lathe for finish boring, the **powder chamber** is bored out and the **compression slope** is cut. The gun is now **bore-searched** and **star-gauged** again and for the final time.

RIFLING. — The bore is now **rifled**, a **system of spiral grooves** being cut in the surface of the bore from the muzzle to the **shell-centering slope** or **band seat.** All rifling is done from the muzzle end of the gun with a specially designed tool consisting of a long (rifling) bar and a rifling head mounted or carried on the end of it. After rifling, the **lands** and **grooves** are carefully star-gauged.

FINISH TURNING. — After rifling, the gun is returned to the lathe, and the **outside turned down to finish diameter, ends faced off to correct length, and bell muzzle cut on.**

The final steps are now taken, such as, **threading the screw-box**; **fitting in the breech mechanism**; **milling the slide keyway**; putting on **the yoke for the piston-rods**; **balancing for center of gravity**; and finally **weighing** and **inspecting.**

NAVAL PROVING GROUNDS. — After final testing at the gun factory, the gun is marked with the place of manufacture, year, mark and modification number, and weight of gun; also the initials of superintendent and inspecting officer. The breech mechanism is tested; the gun is fitted to the slide and as much of the rest of the mount as necessary and is sent to the **Naval Proving Ground at Indian Head, Maryland. Here the gun is fired at least five times** and, if satisfactory, is returned to the gun factory where it is again bore-searched, star-gauged, and is issued to the Service for use.

PRINCIPLE OF CONSTRUCTION

Present requirements for guns demand muzzle velocities of from 2500 to 3150 feet per second. Lower velocities give less striking force, and, more important still, a projectile fired at low velocity would describe a curve so high in the air,

for long ranges, that hits could not be made unless the range were known with great accuracy.

Since the accurate determination of range is the most difficult problem in naval gunnery, the **high-power gun is a necessity.** High velocity of projectile is produced, of course, by high pressure upon it while traveling through the gun bore. **No heavy gun of a single piece of metal, whether cast or forged, could withstand the high pressure generated within the modern high-power gun.** Therefore the peculiar methods of modern gun construction are necessary.

A gun may be considered as a tube designed to withstand a given pressure from within, throwing a projectile which shall produce certain effects at given distances. In constructing such a tube, we must first consider what pressures it will have to withstand at the various points of its length, and then make it strong enough to insure perfect safety. The bore should also be of such material as to stand the wear and tear of firing a large number of rounds without being so damaged by expansion or abrasion as to interfere with the shooting.

Reduced powder charges are now used in major-caliber guns at target practice to prevent erosion or deterioration of the gun bore by expansion or abrasion during firing.

Summing up the requirements of a gun: not only must it be sufficiently strong, but it must not be too heavy; so it is important that the material shall be arranged in such a manner that there may be no waste of its strength — in fact, so arranged that every part shall perform its own share in withstanding the pressure from within. Shortly after the projectile begins to move in the gun bore, the pressure inside the gun decreases, and continues to decrease as the projectile approaches the muzzle; **for this reason the gun is made stronger at the powder chamber than toward the muzzle end.**

To meet the foregoing requirements the Navy has resorted to a system of construction termed the "built-up system", in which the gun is constructed or made up of a number of separately constructed parts or hoops; these being assembled, as has been described, by shrinking the hoops on one over

the other. It has been proved mathematically that **a built-up gun properly constructed, of the same dimensions and material as a cast or homogeneous gun (one solid piece of metal), is much stronger than the latter.**

The **PRINCIPLE OF INITIAL TENSIONS** is used in constructing built-up guns. **This consists in giving to the exterior parts or hoops of a gun a certain initial tension or stretch, gradually decreasing toward the interior, and giving to the interior parts a certain normal state of compression, by the grip of the outer parts or hoops.**

If, by the system of initial tensions, the interior hoop or gun tube can be put in a state of compression, within the elastic limit of the metal, **the amount of that compression is so much additional strength,** since it must be overcome by the pressure of the powder gases before any tension can be exerted on the fibers of the interior gun tube. In order to exert this compression of the gun tube, the **outer hoops must be in a state of normal tension, and in addition they must have a margin of strength within their elastic limits to withstand the additional tension transmitted by the explosion of the powder charge within the gun.**

The exact amount of compression and tension for all parts of the gun when at rest, or when resisting the explosion of the powder charge, so that no part shall be strained to a point exceeding its elastic limit, is determined mathematically for each gun hoop before the gun is assembled.

This calculation involves the **BASIC PRINCIPLE OF GUN CONSTRUCTION,** which is, **that no fiber of any cylinder or hoop in the gun must be strained beyond the elastic limit of the metal of that cylinder.** The straining of the metal of any part of a gun beyond its elastic limit might cause the rupture of the gun, and would, in any event, make its discard necessary.

SHRINKAGE is the means employed to **assemble built-up guns on the principle of initial tensions.** As described under the manufacture of the gun, the jacket or B_1 Hoop is expanded by heat and shrunk on over the gun tube in the shrinking pit, the inner tube being kept cold. As the outer

hoop (the jacket) cools, it **compresses the gun tube,** making the diameter of the tube a little smaller than it was before. The amount by which the diameter of the gun tube is decreased is called the **compression.**

Also, the outer cylinder, or **jacket, is stretched** on account of the resistance of the inner tube, and its diameter is slightly increased. The increase is called the **extension or tension in the metal.**

It should be evident that in the firing of a built-up gun, constructed on the principle of initial tensions, the expansion of the metal will be taken up within the gun itself; that is, the entire expansion will take place between the bore and the outer hoop, owing to the compression of the inner tube and the state of tension in the outer hoops.

Expansion in this manner, under firing conditions, prolongs the life of the gun and reduces erosion and expansion of the gun bore.

RELINING A GUN

After a number of service firings the bore of a gun becomes **eroded** or **expands** and makes **accurate firing impossible.**

This is remedied by unshipping a gun and returning it to the gun factory, where the **gun is re-bored, a liner inserted,** and **the liner rifled and chambered** (as far as necessary).

The operation is briefly as follows: the gun is placed in a large lathe and bored accurately in a taper increasing from the muzzle toward the breech, the taper being, .003 inch to the inch.

The whole gun is now lowered, muzzle down, into the hot-air furnace and heated to a temperature of from 400° to 500° F. When the gun is sufficiently heated and expanded, the liner, which has been previously prepared and machined in a taper to fit the gun, is lowered cold into the gun from above the furnace, being suspended from an overhead crane.

When the liner has been seated in the gun, the heat is turned off the furnace and a section of the furnace is removed to permit circulation of cold air for cooling.

Pressure is put on the liner at the breech end of the gun to prevent its backing out, due to its taper toward the breech, as the gun cools. After the gun has thoroughly cooled and the liner has "**set**", the gun is removed from the furnace, finish bored, rifled and chambered, sent to proving grounds for test, and completed as previously described for the gun as originally constructed.

CHAPTER III

GUN MOUNTS FOR BROADSIDE AND MINOR-CALIBER GUNS

PRINCIPAL PARTS — RECOIL MECHANISM — ELEVATING AND TRAINING GEAR — DETAILS 5-INCH AND 3-POUNDER MOUNTS

GUN MOUNT is the term applied to the entire mechanism or structure between the deck of a ship and the gun itself, which serves to support the gun, and provides for its training, elevation, recoil, and counter-recoil.

The principal parts of a modern mount are the **stand, carriage, slide,** and **recoil cylinders.**

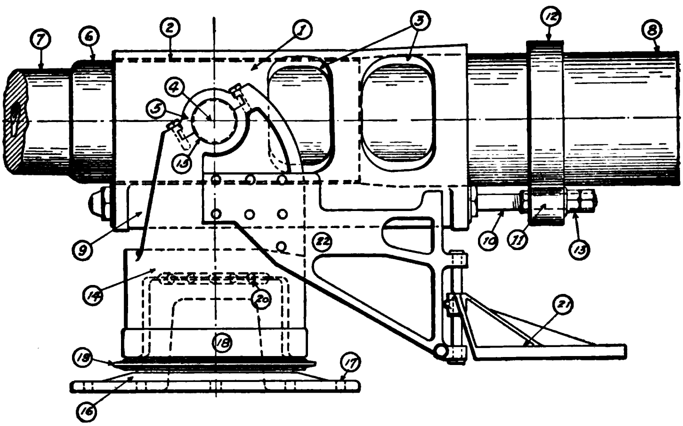
The **STAND is that part of the mount which is secured to the deck of a ship by means of heavy bolts.** It is the stationary support of the whole gun from the ship's deck. It is on top of the stand that the carriage is supported and moved in train or in horizontal movement of the gun.

The **CARRIAGE is that part of the mount which is supported on top of the stand and moves with the gun, carrying it in train.** The carriage has no movement in elevation with the gun, but **has seats, called trunnion seats, in which the supports or trunnions of the slide rest.** Interposed between the top of the stand and the carriage are roller- or ball-bearings which facilitate revolution of the carriage on the top of the stand.

The **SLIDE is that part of the mount which carries the gun barrel itself and moves in elevation** with the gun inside the carriage, being elevated and depressed on trunnions which are a part of the slide, projecting from it like lugs, one on each side, at the center of gravity or balance point of the slide and gun combined. **The slide encircles the**

gun and derives its name from the fact that the gun slides through it in recoil and counter-recoil. The slide is part of the mount and is stationary during recoil.

RECOIL CYLINDERS provide for checking the gun in recoil and returning it to "in battery" position after recoil.



GUN MOUNT—MEDIUM CALIBER BROADSIDE GUN

Side View

1, **Gun slide**; 2, Slide keys—keys on slide cylinder of gun; 3, Openings in slide; 4, Trunnion of slide; 5, Cap square—upper part of trunnion seat; 6, Slide cylinder of gun; 7, Chase of gun; 8, Breech end of gun; 9, **Recoil cylinder**—two—one on each side; 10, Piston rod of recoil cylinder—bolted to yoke of gun; 11, Lug on yoke—secures end of piston rod—two; 12, Yoke—shrunk on over breech end of gun; 13, Lock nuts—secure piston rod to lug of yoke; 14, **Carriage**—fits over stand; 15, Trunnion seat—top of carriage—one each side; 16, **Stand**—bolt to deck; 17, Bolt holes; 18, Hollow space inside stand; 19, Friction disk—training gear; 20, Roller bearings—between stand and carriage; 21, Gun pointer's stand or platform; 22, Metal framework supporting pointer's stand on carriage.

The cylinders are two in number on broadside guns and one on minor-caliber guns. **They are a part of the gun slide and are either made in the same casting with the slide or are firmly bolted or attached to it.**

The cylinders are kept constantly filled with liquid (80% glycerine and 20% water). The motion of this liquid about the piston head during recoil of the gun checks the recoil and eases the gun at the end of recoil. The glycerine in the solution gives a much heavier liquid than water for checking the recoil and also **prevents the liquid in the cylinders from freezing.**

The piston rods, with the piston heads on the end of them, are attached to the gun itself and move with it in recoil. To the gun, shrunk on over the rear cylinder, near the breech, is a heavy steel band or **yoke.** Projecting from this yoke on the under side of the gun are two heavy lugs into which the after or breech ends of the piston rods are securely fastened by lock nuts. **By this means the piston rods and the pistons which move in the recoil cylinders are made a part of the gun, while the cylinders in which they operate are a part of the slide of the mount. Thus, when the gun is fired, the gun, piston-rods, and pistons go to the rear, the pistons operating in the recoil cylinders which remain stationary, checking the recoil of the gun.**

During recoil the pistons or piston heads move along inside the cylinders and the recoil is checked by the friction of the liquid as it passes from one side of the piston head to the other, through apertures of variable area. **The apertures consist of a number of shallow grooves cut longitudinally or lengthwise in the inside wall of the cylinders.** The variable area is obtained by tapering the depth of the grooves, from their greatest depth at the forward end of the cylinder, until they finally disappear when the limit of safe recoil is reached, or when the piston-head is at the after or breech end of the cylinder. When the gun is "**in battery**", the piston head is at the forward or muzzle end of the cylinder, at the deepest part of the grooves. The grooves in the cylinder are from three to five in number, depending on the caliber of the gun. **During counter-recoil of the gun, the liquid again passes over or around the piston head, aiding in controlling the gun's return to "in battery" position.**

Counter-recoil springs are located in the recoil cylinders, their principal function being to return the gun to battery after recoil. These springs surround the piston-rods, being located between the piston head and the cylinder head (breech end). The springs are in a state of initial compression, having a tendency to spread out, this serving to keep the gun " in battery ", during any undue rolling or **movement of the ship. As the gun recoils the springs are highly compressed,** so that when the point of maximum recoil has been reached, the springs assert their tendency to return to a comparatively normal state of compression and return the gun to " in battery " position, the force of the counter-recoil being checked to some extent by the return of the liquid to the after end of the cylinder. In some cases the counter-recoil is rather violent, and larger guns are fitted with **counter-recoil checks** consisting either of spring-buffers or hydraulic checks, located in the forward end of the cylinders.

HYDRAULIC-RECOIL, SPRING RETURN MOUNTS is the term applied to such mounts as have been described in the foregoing paragraphs. All naval mounts now manufactured are of this type.

PEDESTAL MOUNTS

PEDESTAL MOUNTS are now used for all guns from **four- to seven-inch calibers inclusive** *i.e.*, all broadside battery guns not in turrets. The term explains itself, the stand of the mount being in the form of a column or pedestal with a flanged base which is bolted on to the ship's deck. **These mounts may be placed very close to the side of a ship, thereby giving a greater training arc to the gun** for a given size of gun port.

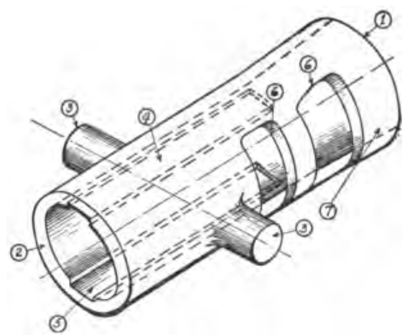
The following named principal parts make up a broadside pedestal mount: (1) **stand,** (2) **carriage,** (3) **slide and recoil cylinders in one,** (4) **recoil mechanism,** (5) **elevating gear,** (6) **training gear.**

The **STAND** is the same in principle as that described for

gun mounts in general. It is in the form of a pedestal, the base being flanged out and securely bolted to the deck of the ship. The top provides a seat for the carriage to revolve on.

The **CARRIAGE** either pivots inside of or fits over the stand. **Either ball bearings or cylindrical rollers are interposed between the carriage and stand to reduce friction and facilitate movement in train of the carriage and gun on the stand.**

The **SLIDE is supported in the carriage on frictionless trunnion bearings.** The **trunnions** project one from each side of the slide after the fashion of lugs, at the center of gravity or balance of slide and gun combined. The trunnions rest or pivot in trunnion bearings or seats in the carriage and this permits of elevation of the gun. **Frictionless trunnion bearings** reduce friction by means of small spherical rollers in the bearings and thus facilitate elevation and depression of the gun.



GUN SLIDE-SKETCH SHOWING TRUNNIONS

(Recoil Cylinders not attached)

1, Breech end of slide; 2, Muzzle end of slide; 3, Trunnions; 4–5, Keyways—top and bottom of slide; 6, Openings in slide to reduce weight, etc.; 7, Note slightly enlarged diameter of breech end.

The **SLIDE AND THE RECOIL CYLINDERS** are either made in one casting, or are securely fastened or bolted together, the cylinders being stationary with the slide during recoil of the gun.

The **RECOIL MECHANISM** is identical with that described for gun mounts in general for broadside guns. **The recoil cylinders are a part of the gun slide and the pistons and piston-rods operating in the cylinders are a part of the gun,** being attached to the gun by lugs on the yoke. The

cylinders are filled with liquid composed of 80% glycerine and 20% water to check the recoil and are equipped with counter-recoil springs to bring the gun back "in battery" after recoil.

The **ELEVATING GEAR is the mechanism that controls the movement of the gun in its vertical plane**; that is, controls the elevation and depression of the axis of the gun bore at the muzzle to accomplish lesser or greater range of firing.

Elevation or depression of a gun muzzle is brought about by the actuation of mechanism consisting of a system of gears, by an **elevating wheel located on the left-hand side of the gun carriage.** This elevating wheel is **operated by the gun pointer,** who is in charge of the pointing of the gun and the firing; the handle on the elevating wheel being fitted with a push button which makes the connections necessary to accomplish electrical firing.

The elevating wheel is placed most advantageously for the pointer, a little below shoulder height. The **pointer stands on a small platform which is secured by brackets and bolts to the gun carriage, and therefore moves with the gun in train.** A body rest is provided for him, so that he may rest his body in the least tiresome position, keep his eyes at his telescope sight, and elevate and depress his gun as necessary, with both hands on the elevating wheel handles.

The elevating wheel has its plane vertical and parallel with the vertical plane through the axis of the gun bore. It is a double wheel having two faces, each of which operates in a reverse direction by its own handle. **The handles are at opposite sides of the center of the wheels,** so that the motion of the operator's hands is similar to the motion of the pedals of a bicycle. The handles themselves revolve or spin on their supports or connections to the wheels, to permit the hands being kept on them.

The elevating mechanism consists principally of a toothed concave arc and a small pinion wheel under the center of the gun, the arc being secured to the bottom of gun slide,

and the pinion being fixed in position relative to the mount. Motion of the elevating wheel revolves the pinion and its teeth, engaging those of the geared arc, cause the arc and consequently the slide and the whole gun to elevate or depress. There is also provided a worm-gear operating on a shaft parallel to the axis of the gun, this worm-gear being capable of longitudinal motion along the shaft. It is supported at one end by a spiral spring surrounding the shaft. The worm-gear and shaft are connected up with the elevating arc and pinion, and by virtue of the longitudinal motion of the worm and the spring at its one end, the elevating gear is enabled to "give" slightly under recoil of the gun when all the extra weight is thrown on it. The worm-gear and spring also serve to take up any loose motion in the elevating gear. Were it not for some such arrangement as described, the elevating gear would be strained and the teeth probably stripped from the arc or pinion during the recoil of the gun, when the whole weight of the breech end is thrown back out of the slide.

The **TRAINING GEAR is the mechanism that controls the horizontal movement or "train" of the gun.**

Pedestal mounts of the older types were trained by a system of gearing. This included a geared training rack fitted to the gun stand, and a system of shafts and worm gears connecting this training rack to the **gun trainer's hand-operating wheel located at the right-hand side of the gun carriage.**

The **training wheel is operated by the gun trainer**, who has a position on the right side of the gun similar to that occupied by the gun pointer on the left side. The trainer operates the training mechanism to keep the gun or the cross-wires of his telescope on the target. He also operates the training mechanism as directed by the gun pointer, who calls to him, "**train right**" or "**train left**" as desired. This is called "coaching" by the pointer.

The **training wheel is identical in construction and operation with the elevating wheel** and the **trainer takes his position on a stand attached to the carriage at the right**

side of the mount, similar to that occupied by the pointer at the left side.

FRICTION TRAINING GEAR. — On all new types of broadside guns, instead of a geared training arc or rack on the gun stand there is a friction disk. This disk has a rough abrasive surface and is secured to the lower part of the gun stand surrounding it. When the gun is trained, rollers or disks, also abrasive, are actuated by the trainer's operating wheel and bear on the rough surface of the friction disk, causing the gun carriage and gun to revolve in train.

Friction disks for training have advantages over gears in that there is little or no lost motion, they are simpler in construction, and easy to keep in order. Any pressure on the side of the gun muzzle such as to force it to one side or other would simply cause the gun bearing on the friction disk to slip. With a geared rack the teeth would have been stripped from it. This last might occur when other vessels, particularly colliers, come alongside. The guns should, of course, have previously been trained in close to the ship's side.

GUN SHIELDS of three-inch armor-steel are used in gun ports to protect the crew of the gun during an action. These shields are semicircular and extend around the gun, outboard of the mechanism. They are bracketed to the gun carriage and consequently move around with the gun in train. A port or opening is provided in the center of the shield through which the muzzle of the gun extends. This port is only large enough to permit the gun to be elevated through its prescribed arc, and to give the pointer an opening to see through.

FIVE-INCH GUN MOUNT

The following brief summarized description is given of a five-inch gun mount of the latest type.

Stand — Pedestal type; is bolted to deck; has roller path on top.

Carriage — Sets on rollers on top of stand; moves in train.

Typical Gun Mount — Minor-Caliber Guns, Side View — 3-Pounder, Semi-Automatic Gun

1, Stand — cage type — flat side against ship's rail; 2, Socket joint — for training gun — carriage fits into; 3, Carriage — Y-shaped — pivots in socket (2) of stand; 4, Slide — pivots in carriage — carries gun; 5, Trunnion of slide; 6, Recoil cylinder — one under gun — part of slide; 7, Elevating and training clamps; 8, Shoulder bar and deflector — attached to slide.

Slide — Non-recoiling part of mount of which trunnions form a part; moves in elevation inside of carriage on **frictionless trunnion bearings.** Part through which gun moves in recoil.

Recoil Cylinders — Two below gun, one located on each side; are a part of the slide. Pistons and rods are secured to yoke on gun. Filled with glycerine and water to check gun in recoil. Counter-recoil springs inside bring gun back "**in battery.**"

Gun Shield — Secured to carriage. Semicircular, 3-inch armor. Protects crew.

Elevating Gear — Heavy elevating arc and pinion under center of gun, operating through system of worm gears and actuated by **elevating hand wheel** on left side of mount.

Training Gear — Friction disk at bottom of gun stand. This has a rough or abrasive surface. Carriage is revolved by friction, rollers bearing on friction disk and being actuated by **training hand wheel** on right side of mount. Suitable gearing from operating wheel to disks or rollers is provided.

Variable speed clutches are provided for both elevating and training mechanisms. Increase speed of motion of gun when desirable.

Telescope Sights — Two are provided, one each for pointer and trainer. Attached to sides of slide by heavy **sight brackets.** Eye pieces of telescopes are at sides of gun and at height of eye.

Platforms and body rests for pointer and trainer, which move with the gun in train.

MINOR-CALIBER MOUNTS

Mounts for minor-caliber guns (1, 3, and 6-pounders) are similar in principle to pedestal mounts for broadside guns.

A description of a six-pounder mount will cover all mounts for minor-caliber guns.

SIX-POUNDER MOUNT

The **mount** is of the hydraulic-recoil, spring-return type.

Stand — Bolted to deck. Cage type. Outboard sector cut off, enabling stand to set up close to ship's side.

Carriage — Rests on stand, moves in train on common socket joint.

Slide — Non-recoiling part of mount. Seated in carriage on trunnions. Moves in elevation inside of carriage.

Recoil cylinder — One; part of gun slide; mounted under gun; piston attached to gun by yoke. Cylinder operates in recoil and counter-recoil as on pedestal mounts.

Shoulder-bar — Used by gun pointer to move gun in train and elevation. Fits to his shoulder and is also equipped with two handles. It is attached to the slide and therefore does not recoil but moves in train and elevation with slide and gun.

Deflector — Curved piece of metal attached to shoulder-bar to deflect empty cartridges as they are ejected from the gun and prevent them from striking pointer.

Telescope Sight — At rear of gun, permitting pointer to keep eye to lens during firing.

Elevating Clamp
Training Clamp — No elevating or training mechanism is provided. When gun is pointed at a desired range by means of the pointer's shoulder-bar, it may be clamped in train and in elevation.

CHAPTER IV

BREECH MECHANISMS — FIRING MECHANISMS

TYPES AND GENERAL PRINCIPLES — ACCESSORIES — DE BANGE GAS-CHECK SYSTEM

BREECH MECHANISM is the term applied to the entire mechanical device that is employed for closing the rear end of the chamber or bore of a breech-loading gun. It includes not only the **breech-block or plug itself, but also all mechanism connected with it and the gear that operates the plug and its mechanism.**

Certain requirements have been laid down as being essential to the satisfactory and efficient operation of breech mechanisms in general. These may lead to a more thorough understanding of the mechanism and are outlined in brief as follows: (1) **Safety** — the escape of any gas to the rear, through or around the plug, must be effectually prevented; the mechanism must be strong enough to withstand any pressure generated by the explosion of the powder charge in the gun chamber, so as to prevent any part of it from being blown to the rear; the breech-block or plug must be securely locked to prevent opening on firing; and the danger of premature firing of the gun must be minimized. (2) **Simple in design and easy to operate** — this is necessary in order that rapid, continuous fire may be maintained in action. (3) **Easy to repair and interchangeability of parts.** All parts should be so accurately made that they are interchangeable with any similar part. The whole mechanism should be capable of being mounted on any similar gun. Parts most exposed

to wear should be designed so as to permit of easy replacement. If during an action any part should break, it must be possible to renew it so as to resume firing of the gun in the shortest possible time.

There are **THREE PRINCIPAL TYPES OF BREECH MECHANISMS** in general use in the Naval Service today.

(1) The **interrupted-screw system,** used on practically all guns of 3-inch caliber and above (**broadside and main battery guns**).

(2) The **sliding wedge,** usually designated as the **Hotchkiss sliding wedge** from the name of the inventor. This is used on practically all guns of minor calibers, or on guns from 1- to 6-pounders. There are two other types of mechanisms used on these small guns, but their use is restricted to guns of particular types, so mere mention of the mechanisms will suffice. They are the "combined sliding and rotary block system" used on **Driggs-Schroeder** guns only, and the "combined rotary and sliding wedge" used only on **Nordenfeldt** 3- and 6-pounders. There are comparatively few guns of either of these types still in service. The operation of the mechanisms is somewhat similar to the Hotchkiss sliding wedge, except that each combines with the wedge a distinctive rotary motion.

(3) The **sliding bolt** is used on small arms such as the Springfield rifle; also on automatic and machine rifles.

The **INTERRUPTED-SCREW BREECH MECHANISM** is, as said before, used on all broadside and main battery guns, including practically all guns of three-inch caliber and above.

It is subdivided into several different types of interrupted-screw systems.

(1) The **ordinary interrupted-screw** system, sometimes designated the **French interrupted-screw.** In this type the breech-block or plug consists of a cylinder, which has first been threaded all the way round, and then had several (two or more) sections of the thread removed in the direction of the axis of the cylinder or plug. This gives an equal number of threaded segments and blanks, equally spaced

around the circumference of the plug. In the female thread or the screw-box of the gun, similar interruptions are made, so that when the plug is seated in the screw-box, the threads are locked together by revolving the plug a slight amount about its axis. Similarly, a portion of a turn will unlock the plug, bringing the threaded sections of the plug opposite the blanks of the screw-box and permitting the plug to be withdrawn straight to the rear, thus opening the breech.

The system of breech mechanism described in the foregoing is found in use on practically all guns of three-inch calibers, and on older types of four- and five-inch guns.

(2) The **WELIN INTERRUPTED-SCREW OR STEP-THREADED SYSTEM** is now being used on the breech mechanisms being mounted on all guns, from and including four-inch calibers up to sixteen-inch.

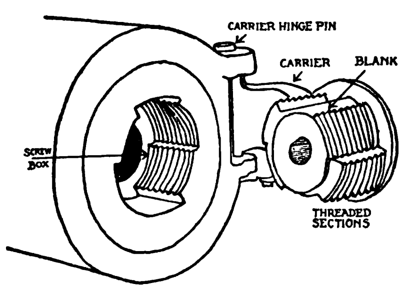
Instead of utilizing a mere "thread and blank" system, as in the French interrupted screw, the Welin system employs several threaded sections on the plug to every blank, the blank being of smallest radius and each threaded section being of slightly greater radius than the preceding "step." For example, a plug is first divided around its circumference into three equal parts. Then each part is further divided into four equal parts. Taking the four parts of each section, the one of smallest radius is a blank. The next three, each of which is threaded, are stepped up from the blank section and from each other, in steps of equal size. We have now around the circumference of the plug twelve sections, nine of which are threaded; all threaded sections being those of largest diameter.

The screw-box which receives the plug is cut out and step-threaded similarly to the plug, except that the blank sections in the screw-box are the parts of largest diameter, while the threaded sections are the parts of smaller diameter.

In closing the breech of the gun, the plug first moves straight into the screw-box actuated by the operating handle, the threaded sections of largest diameter on the plug sliding in next to the blank sections of the screw-box and each other threaded section on the plug sliding in next to the

threaded section of one step larger diameter of the screw-box. The plug, still actuated by the operating handle, is now revolved through an arc equal to the width of one section of the plug and screw-box, or through an arc equal to one twelfth of 360° or 30°. This locks each threaded section of plug and screw-box.

Pointing out a singular advantage of the Welin system over the ordinary or French system : in the former, the plug is securely locked around three quarters of its circumference, while in the latter the plug is locked around only half of its circumference.



WELIN STEP-THREADED PLUG

There is still another system of interrupted-screw called the **Elswick system.** This is only found in use on some of older type, small-caliber guns, and is of little importance. It employs a plug, or screw-block, the forward part of which is conical and the after or breech end of which is cylindrical. Both coned and cylindrical parts are equally threaded and blanked, the threaded sections of the cone being in line or corresponding longitudinally with the blank sections of the cylinder and vice versa.

The **HOTCHKISS SLIDING–WEDGE** system is used on practically all minor-caliber guns from one- to six-pounders.

It consists essentially of a rectangular, wedge-shaped block which slides up and down in a vertical mortise joint within the square-shaped breech of the gun, being guided in its up and down movement by vertical ribs in the breech and grooves in the side of the wedge or block.

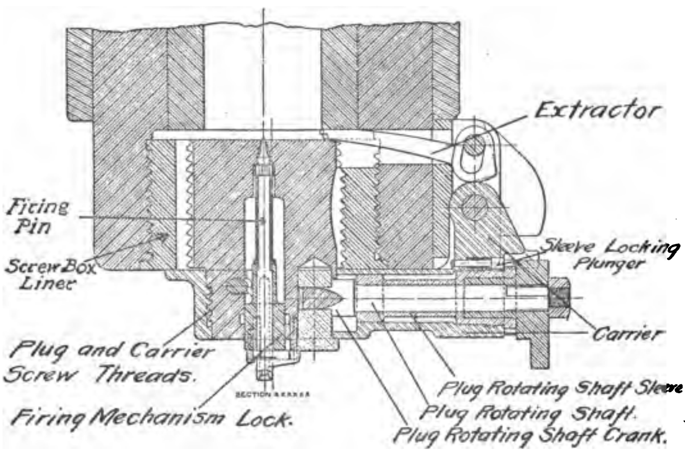
The block is actuated by a crank or lever in the right side or cheek of the breech. The inner end of the crank is fitted with a stud which engages in a groove in the right side of the wedge. When the crank is moved to the rear,

the stud on its end operates in the groove of the block and causes it to drop, opening the breech and exposing the gun bore. In loading, a cartridge is shoved in the gun bore, and the crank or handle is operated, bringing the block up in position and closing the breech. The block itself is slightly wedge-shaped, thus aiding in seating the cartridge in the bore, by a sliding movement as it comes up into position when the breech is closed.

The firing pin and mechanism are all contained in the block itself, giving a safety device that will not permit the gun to be fired until the breech is fully closed.

PRINCIPAL PARTS OF BREECH MECHANISMS

The **BREECH–BLOCK OR PLUG** is the principal part of every breech mechanism, whatever the type. It is the movable piece which closes the breech of the gun — the part that



RAPID-FIRE GUN BREECH. CROSS-SECTION THROUGH PLUG SHOWING FIRING-PIN

is withdrawn before loading, and closed and locked before firing. It is seated, in the case of an interrupted screw breech mechanism, in a **screw-box**.

The **SCREW–BOX** is really a part of the gun and has already been described in connection with gun parts. It is carried usually by the jacket of a gun, or partly by the jacket and another hoop. In the latest type of a gun the screw-box is carried in a **screw-box liner** inside the jacket of the gun. This liner is merely a bushing shrunk or screwed inside the jacket and then threaded to receive the plug.

The **CARRIER**, which is an arm extending across one side of the breech face of the gun. One end is hinged to the breech of the gun. The other end carries the whole plug when it is swung clear of the screw-box in opening the breech.

The **HINGE–PLATES** are plates securely fastened to the gun, and carry the sockets in which the **hinge-pin**, which fastens the carrier to gun, rests and operates.

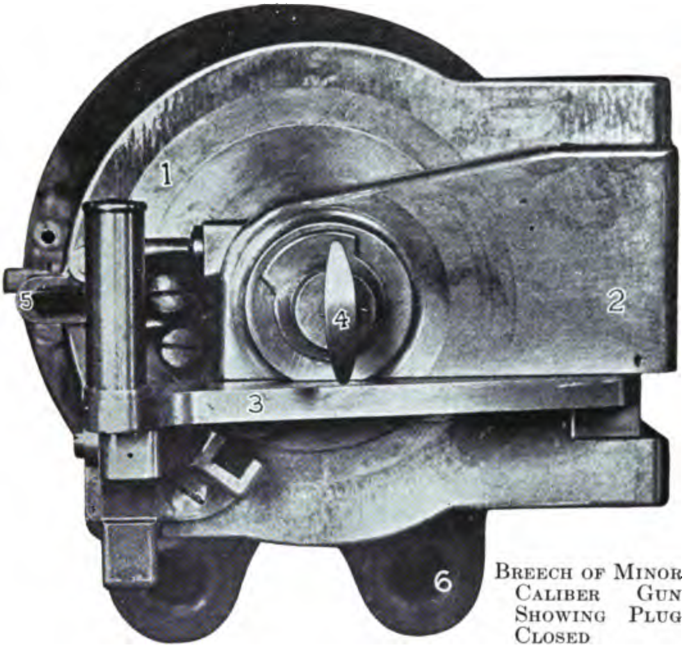
The **OPERATING–LEVER** is the handle or crank that actuates the mechanism which operates to open and close the breech.

The foregoing are the essential parts, only, of breech mechanisms in general.

GAS CHECKS

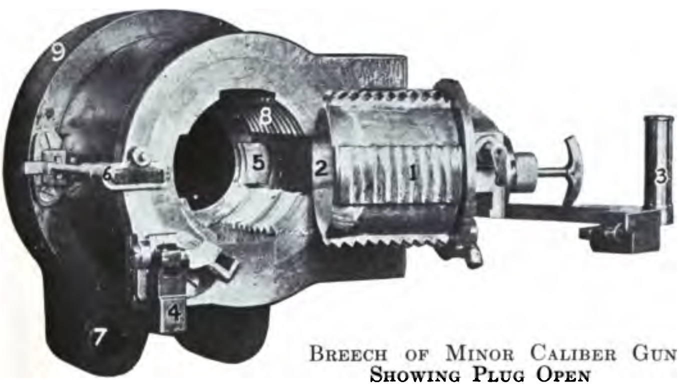
Every breech mechanism must have some means of effectually preventing the escape of powder gases to the rear, through the breech, after a gun is fired.

In the case of rapid-fire guns using fixed ammunition, the problem is simply solved by utilizing the **metallic cartridge case as a gas check.** The heat and pressure of the powder gas, on firing, expand the mouth of the cartridge case against the gun chamber and keep the gas from escaping to the rear. Before the projectile leaves the cartridge case, the powder gas, being confined, causes the case to swell out and fill the chamber, before enough pressure is generated to expel the projectile from the case and the gun. In the case of **semi-fixed ammunition,** metallic cartridge case and projectile being separate, a **mouth-cap,** or heavy wad, is used to close the case and thus confine the gas sufficiently to have the cartridge case act as a gas check.



BREECH OF MINOR CALIBER GUN SHOWING PLUG CLOSED

1, Plug; 2, Carrier; 3, Operating handle; 4, Cocking piece; 5, Trigger for percussion firing mechanism; 6, Lugs for piston rods.



BREECH OF MINOR CALIBER GUN SHOWING PLUG OPEN

1, Plug — French interrupted screw; 2, Firing-pin hole in inside face of plug; 3, Operating handle; 4, Salvo-latch; 5, Extractor lug; 6, Trigger for percussion firing mechanism; 7, Lugs for piston rods; 8, Screw-box; 9, Yoke carrying lugs for piston rods.

In the case of all breech-loading rifles, or guns using separate ammunition, an additional device is necessary.

THE DE BANGE GAS CHECK is the only system or device of this nature used in the U. S. Navy. **It is fitted to all breech-loading rifles.**

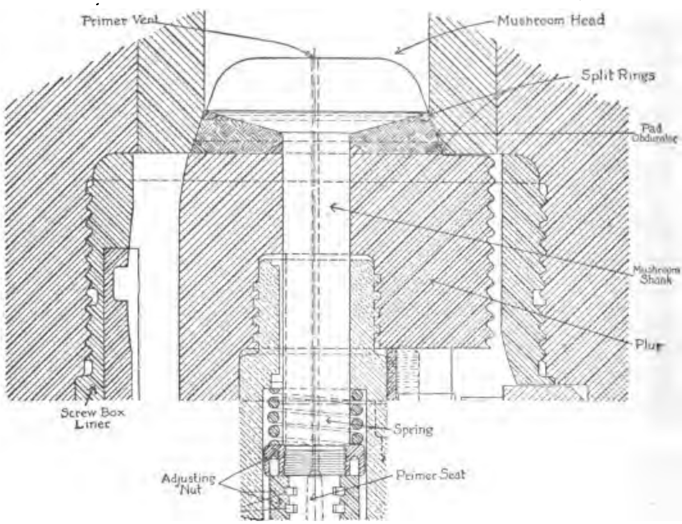
It consists of a mushroom-headed piece of steel with a shank, the shank passing through a hole in the center of the breech-block or plug in the direction of its axis. Between the mushroom head and the forward face of the plug are secured two thin steel disks or split-rings, each about one quarter inch thick. **Between these split rings is secured a " pad-obturator " consisting of a circular pad composed of 65% asbestos and 35% mutton tallow, and covered with canvas.** The pad averages about one to one and one half inches thick. Both split rings and pad fit over the shank. **Lock nuts** screwed on to the rear part of the shank, within the recess of the plug, securely bind together all the parts. A **short heavy spiral spring** surrounds the mushroom shank at the breech end, bearing against the forward part of the lock nuts and against the after recessed face of the plug. Thus, by tightening up on the nuts, the shank and mushroom head are carried toward the breech and the pad is pressed out farther, or forced to expand radially. Also, when the gun is fired, this spring permits the mushroom head to give slightly to the rear, which spreads out the gas-check pad.

The mushroom is prevented from turning in the plug by a mushroom key fitted to the plug and which slides **into a keyway on the mushroom stem or shank.** Through the mushroom stem a small vent extends from end to end, enlarging at the breech end to form the **primer seat.** At the forward end the vent goes out through the mushroom head. This is called the **primer vent,** as it is the hole through which the primer flame shoots, needle fashion, when the gun is fired. It is about one eighth of an inch in diameter.

The rear end of the mushroom shank, which contains the primer seat, is also fitted to receive the **firing lock,** the lock fitting over the stem, usually by means of a bayonet joint or by an ordinary screw thread.

When the breech plug is closed, the mushroom head and pad project beyond the screw-box into the gun chamber, the front disk and the pad bearing on the gas-check slope of the gun chamber.

When the gun is fired, the powder gases acting on the face of the mushroom force it back, the mushroom spring giving slightly, causing the pad between the steel rings to



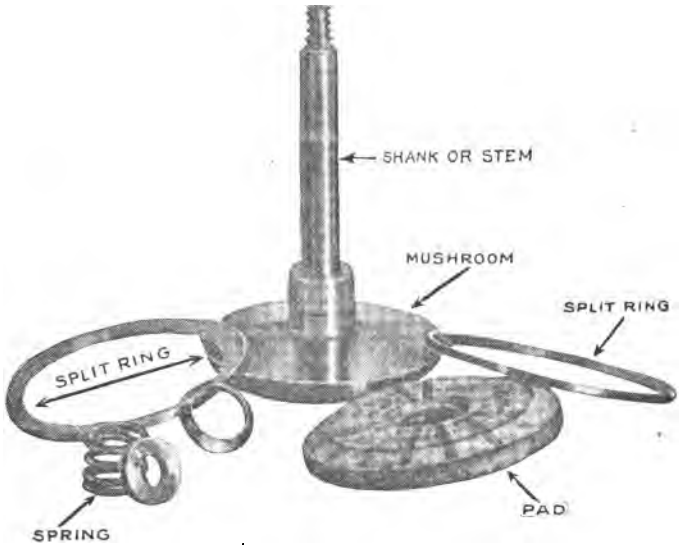
De Bange Gas Check, Plug Closed

be compressed by the motion of the mushroom head toward the stationary plug. **As it is compressed, the pad expands radially and equally all around against the gas-check seat, or slope of the gun, sealing all escape of gas to the rear.** The greater the pressure brought to bear on the face of the mushroom, the more effectual is the check.

This De Bange gas check has many excellent points, including principally, certainty of action, easy replacement, easy adjustment and durability. The pads in actual use last anywhere from 200 to 1000 rounds. If damaged, they can be replaced in a relatively short time.

The **GAS–EJECTOR system is sometimes included as a part of the breech mechanism of a gun.** More properly it is a separate device and has been so treated, a detailed description of it being given elsewhere.

The function of the gas ejector is to shoot jets of compressed air into and through the chamber and gun bore after



Gas-Check Mechanism Dis-Assembled

firing and before the plug is open, the purpose being to blow all unexploded gases and residue, burning fragments, etc., out through the muzzle before the next loading. Its principal function is to guard against **flarebacks,** which occur when fresh air from the opened breech comes in contact with unexploded gases remaining in the bore and with any burning fragments also remaining. Ignition is caused, with the resultant flareback in the faces of the gun crew.

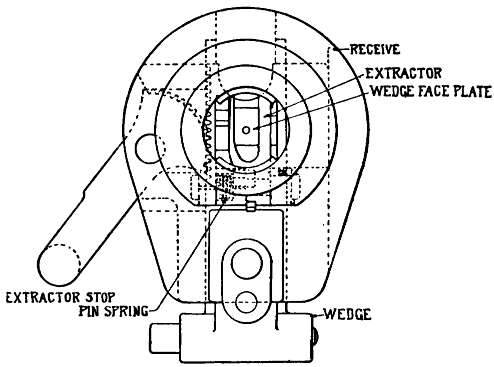
The gas ejector is operated automatically by the breech plug as it starts to open, tripping a valve on the breech face of the gun. By the time the plug is wide open, the air has

been on for several seconds and the bore is clear. The air is shut off by hand by a member of the gun crew.

FIRING MECHANISMS

FIRING MECHANISM is the term used to designate that part of the breech mechanism which directly explodes the primer and thus fires the gun.

FIRING–LOCK is the term applied in practice to the firing mechanism on a separate ammunition gun. It explains itself by its name. It has two principal functions:



FIRING-LOCK FOR B. L. R. REAR VIEW AS MOUNTED ON BREECH PLUG

first, to lock the primer in position in the primer seat ready for firing; and second, to fire the primer, thus firing the gun.

Guns are fired by percussion and by electricity. Percussion firing is used on guns of 3-inch caliber and below, while guns above 3-inch caliber fire by either percussion or electricity. For all large guns, electric firing is considered preferable and is the only method used, percussion firing being used only as an alternative.

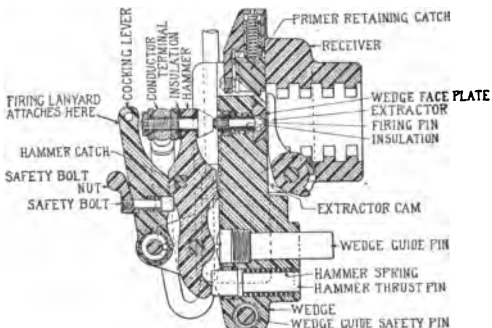
Electric firing connections and attachments are described in detail elsewhere, so that no further discussion of electric firing is necessary here.

Percussion firing mechanism consists essentially of a **firing-pin,** surrounded by a small spiral spring. The firing-pin has an axial movement in the plug (back and forth in the direction of the axis of the plug). . The **firing-pin is cocked** either automatically by the opening of the breech plug, or by hand.

The principal parts of the **FIRING–LOCK** are:

Receiver, which screws on to the rear end of the mushroom shank.

Wedge, carried by the "receiver" and operating to close or unmask the primer seat for inserting a new primer, etc.



Cross-Section through Firing-Lock

Latch, for locking primer in primer seat.

Extractor, for ejecting fired or empty primer case.

Firing-bolt, having a **spring,** and a **sear** for holding the firing-bolt cocked.

Trigger, to release the sear. Rope lanyard may be secured to trigger.

The **wedge** described above, and which covers the primer seat, contains the **firing-pin** and **spring.**

WHEN THE GUN IS FIRED, the trigger is pulled. This releases the **sear.** The sear in turn releases the **firing-bolt,** which jumps forward against the **firing-pin** seated in the **wedge** and causes the **pin** to strike the fulminate of mercury cap of the primer, exploding it.

The term **firing attachments** should not be confused with the term **firing mechanism.** The **firing mechanism** is a part of the **breech mechanism.** Firing attachments are attachments or appliances used to put the firing mechanism in operation and form no part, either of firing or breech mechanisms. They are described in detail later.

DESIGNATION OF BREECH MECHANISMS

TURRET OR MAIN-BATTERY GUN, BREECH MECHANISMS form one general class, comprising two principal types: (1) **Farçot,** (2) **Naval Gun Factory design.** Each type will be described in detail in the discussion of Main-battery gun breech mechanisms.

QUICK-ACTING BREECH MECHANISMS form the other general class, comprising the following principal types:

(1) **Quick-fire,** (2) **rapid-fire,** (3) **semi-automatic rapid-fire,** (4) **automatic rapid-fire.**

A **quick-fire breech mechanism** is a quick-acting one **provided with a gas check and a firing-lock** for use on breech-loading rifles or guns using separate ammunition.

A rapid-fire breech mechanism is a quick-acting one **without a gas check and firing-lock** for use on a rapid-fire gun using fixed or cartridge case ammunition. The name of the breech mechanism also defines the gun.

A **semi-automatic, rapid-fire breech mechanism** is a quick-acting one, the operation of which is partly automatic and partly by hand. The name of the breech mechanism also defines the gun.

An **automatic, rapid-fire breech mechanism** is one wherein all the operations are automatically performed, utilizing the energy of recoil. The name of the breech mechanism also defines the gun.

IN REFERRING TO ANY PARTICULAR TYPE OF BREECH, the customary practice is to give the **Mark** and **Modification** number, together with the caliber of the gun to which it is fitted or for which it is made. There is often added to this for further identification, whether rapid-fire,

semi-automatic, etc. In the case of quick-acting breech mechanisms the name of the inventor is usually used. The system of breech-block is sometimes used.

The following are examples:

Hotchkiss 6-pounder Sliding Wedge, Mark III.

12-inch Breech Mechanism, Welin type, Mark VI.

Chapter V

BREECH MECHANISMS FOR MAIN BATTERY OR TURRET GUNS

FARÇOT AND NAVAL GUN FACTORY TYPES WITH FIRING MECHANISMS — 14-INCH, 3-GUN TURRET DROP PLUG TYPE

Main battery or turret gun breech mechanisms are confined to practically two principal types:

(1) **The Farçot breech mechanism, sometimes called the improved Farçot.** This is the older type and is found in the turrets of most of our pre-dreadnought battleships. The entire movement of the breech-plug is actuated by a heavy crank which is turned or revolved approximately seven turns to open or close the breech.

(2) **The Naval Gun Factory design; also called the Smith-Asbury Breech Mechanism.** This is the very latest type of breech mechanism, and is found on the latest type of 12- and 14-inch guns in both two- and three-gun turrets.

FARÇOT 12-INCH BREECH MECHANISMS, MARKS VI–VII–VIII

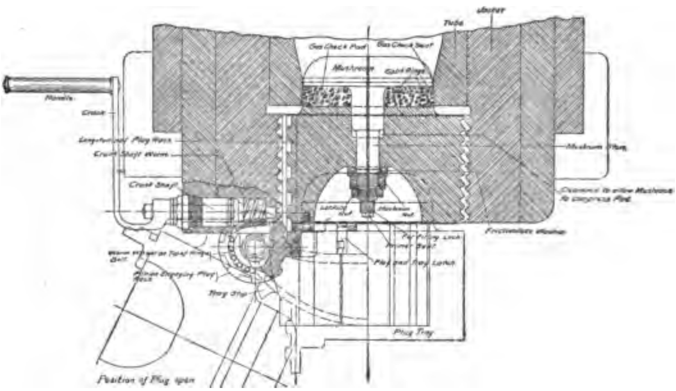
This type of breech mechanism employs the improved Farçot system. All of the mechanisms listed above, 12-inch, Marks VI–VII–VIII, as well as the 10-inch and 8-inch mechanisms in service, are essentially the same in principle, differing only in minor details.

These mechanisms are found in use on many of our modern ships, and on practically all of our battleships of the pre-dreadnought type, such as the ships of the U. S. S. *Con-*

necticut and *New Hampshire* class, the U. S. S. *New Jersey* and *Virginia* class, and the U. S. S. *Ohio* and U. S. S. *Alabama* classes, etc.

A fairly detailed description of the operation of this breech mechanism follows:

The **BREECH–BLOCK OR PLUG** is of the Welin stepped-screw type. For the 12-inch breech the plug and screw-



FARÇOT BREECH MECHANISM. CROSS-SECTION THROUGH PLUG

box are each divided into twelve sections, 9 threaded steps and 3 blanks.

The **DE BANGE GAS CHECK** is employed. The primer seat is in the rear of the mushroom shank or stem. The firing-lock screws on over the rear end of the mushroom stem. The primer-vent is a small hole through the center of the mushroom stem. The mushroom head, with the gas-check pad and steel split rings, is secured to the plug by locking-nuts screwed on to the rear end of the mushroom stem and setting in a recess in the rear face of the plug.

When, during the process of locking or unlocking the plug in the screw-box, **the plug is revolved, it turns on the mushroom stem, which is fixed, and for this reason a ball-bearing washer is interposed between the plug and stem to avoid friction.**

The **OPERATING GEAR** consists of the following principal parts:

Crank or operating-handle
Plug-tray latch
System of gears

There are three steps in the operation of opening or closing the breech: (1) **rotation of the plug** about its axis, which locks or unlocks the threads of the plug and of the screw-box; (2) **translation** or movement of the plug straight to the rear out of the screw-box and on to the plug-tray; (3) **swinging clear of the screw-box** and to the right or left of the breech of the gun, utilizing the vertical hinge by which the plug tray and the breech mechanism is secured to the gun. **The three steps of rotation, translation, and swinging are all accomplished in either opening or closing the breech by the continuous rotation of the crank or operating handle,** the various motions of the plug being effected by means of suitable gearing. **Seven turns of the crank are necessary to operate the mechanism, swinging the plug clear of breech.**

The **OPERATING-HANDLE OR CRANK** serves merely to operate the gearing, which rotates, translates, and swings the plug clear of the breech. The inner arm of the crank, called the **crank-shaft,** is journaled in one side of the breech of the gun or works in revolution in a joint extending usually across the left breech face of the gun. The inner end of this crank-shaft is geared itself and connects with gears so that when it revolves, due to operation of the handle, the whole plug is set in motion.

The **PLUG-TRAY is the mechanism that serves to carry the plug when it is not seated in the screw-box.** It corresponds to the **carrier** on other type breech mechanisms. When the plug is seated in the screw-box, or when the breech is closed, the **plug-tray** projects to the rear from the breech face of the gun. The forward edge of the tray, however, butts close up against the breech face of the gun, **ready to receive the plug when it moves to the rear out of the screw-box.**

Instead of the plug itself being hinged to the gun, **the**

plug-tray is hinged to the left side of the breech face of the gun by a vertical shaft or plug-tray hinge-pin.

On the plug-tray hinge-pin are two geared wheels which operate in the gearing on the operating-handle crank-shaft. Thus, turning the operating-handle causes the vertical hinge-pin to revolve. Revolution of this hinge-pin, together with the geared wheel mounted on it, causes the plug, first to rotate, unlocking from the threads of screw-box; second, to move to the rear on to the plug-tray; and finally to swing on to and be carried by the plug-tray, clear of the screw-box and breech of the gun.

The **PLUG–TRAY LATCH** is a small device or mechanism that firmly locks the plug on to the plug-tray before the plug and tray together can be swung away from the screw-box. It also serves to lock the tray to the gun until the plug has been properly seated on the tray. In closing the breech the reverse action takes place. The tray latch in the closing of the breech also prevents rotation of the plug until the proper moment.

The **GAS–EJECTOR** is of the usual type, six small holes leading to the screw-box from a pipe encircling the breech face of the gun. The valve is located on the upper, left-hand side of the breech face, and is tripped as the plug is withdrawn to the rear.

The **SALVO–LATCH** is also of the usual pendulum type. It is suspended from the lower part of the breech face. It serves to lock the operating-handle and therefore the plug, until the recoil of the gun in firing trips it, or until it is tripped by hand. It is merely a safety precaution to prevent a breech being opened until after the gun has been fired.

The **FIRING MECHANISM** permits of either electrical or percussion firing.

The **firing-lock receiver** screws on over the rear end of the mushroom shank. As stated before, the mushroom and its stem or shank are fixed while the plug revolves. The whole firing-lock mechanism revolves with the plug. The wedge carries the firing-pin and spring, which, in percussion firing, fires the primer and the gun. On this particular

firing mechanism a **wedge extension** is provided, **which extends from the wedge covering the primer seat, across one side of the plug; the other end connecting with a cam or mechanical device on the breech face of the gun.**

When the plug is revolved in unlocking, the **cam on the breech face of the gun** engages the **wedge-extension** which in turn **draws the wedge away from over the primer seat.** The wedge in uncovering the primer seat **actuates the extractor to eject the empty primer case.** Therefore, when the plug is unlocked from the screw-box threads in opening, the empty primer is automatically ejected and the primer seat is left and held open, ready for a new primer to be inserted. In locking the plug, as it is revolved closed, the cam releases the **wedge-extension** and in turn the **wedge** containing the **firing-pin,** which goes back into its position covering the primer seat as the operation of locking the plug is completed. **It is seen therefore that it is impossible to fire the gun until the breech is fully closed as the firing-pin is not in line with the primer until this is effected. The primer in this gun may safely be inserted while the breech is open, and in practice is inserted while the plug is open and the gun is being loaded.**

The **electric firing mechanism** is of the standard design such as is fully described in connection with electric firing connections.

Both electric and percussion firing mechanisms are actuated by the gun pointer from his position at the elevating mechanism.

NAVAL GUN FACTORY DESIGN — 12-INCH BREECH MECHANISM, MARK IX

This type of breech mechanism employs the Naval Gun Factory design or the Smith-Asbury system. It is the latest and most approved type of breech mechanism and is used with slight changes only, on all guns from 12 to 14-inch calibers now being built and installed on the new super-dreadnoughts.

This particular type of twelve-inch, Mark IX breech is used at present on dreadnoughts of the following classes — U. S. S. *Michigan, Delaware, Wyoming, Florida,* etc.

The **BREECH MECHANISM IS OF THE CARRIER TYPE,** differing from the breech previously described which had a **plug-tray** instead of a carrier.

The **PLUG OR BREECH–BLOCK** is of the Welin stepped-screw type, having 16 sections — 4 blanks and 12 threaded steps in 4 groups, the blanks being wider than the threaded steps to permit proper action of the plug operating mechanism.

The **DE BANGE GAS CHECK** is utilized and is of standard type and construction as elsewhere described. The mushroom and stem can move slightly to rear against the mushroom spring, when firing, but is **prevented from rotating by a key attached to the plug carrier.** The **primer-vent** extends through the mushroom head and stem, the rear end of the stem forming the **primer** seat.

The **OPERATING GEAR** consists of the following principal parts:

Carrier
Operating-lever
Operating-lever crank-shaft
Plug-rotating mechanism

In the operation of opening or closing the breech there are three separate and distinct motions of the plug itself. (1) **Rotation** about the axis of the plug to unlock it from the threads of the screw-box. (2) **Translation** or withdrawing the plug to the rear **out of the screw-box by means of the hub of the carrier,** and (3) **swinging** the plug with its carrier clear of the screw-box.

The **CARRIER** corresponds to the **plug-tray** of the Farçot breech mechanism just described. **It serves to carry the plug when the plug is not seated in the screw-box.** It is a heavy steel arm projecting across one side of the breech face of the gun. The end of the carrier at the base of the gun is made with a **heavy hub,** and it is by this hub that the plug is carried, the plug being connected with the hub

by a fixed joint, or, in other words, **the plug is journaled to the hub.** The other end of the carrier is hinged on to the right side of the breech face of the gun, and in swinging the plug clear of the screw-box in opening or closing the breech, **the whole carrier moves on this hinge-pin away from the breech face.**

The **OPERATING–LEVER** is on the right side of the gun. When the plug is closed and locked, this lever inclines upward and toward the muzzle at an angle of about 45°. **To open the breech the handle is first moved to the rear and downward in a vertical plane.** This first rotates and unlocks the plug in the screw-box. **The handle is now swung to the right in a horizontal plane.** This swings the carrier with its hub and the plug to the right clear of the breech. Reverse motions close the breech.

The **PLUG–ROTATING MECHANISM** consists principally of the **operating-lever crank-shaft** with its **overhung pin and crosshead** and the **plug-rotating cam.**

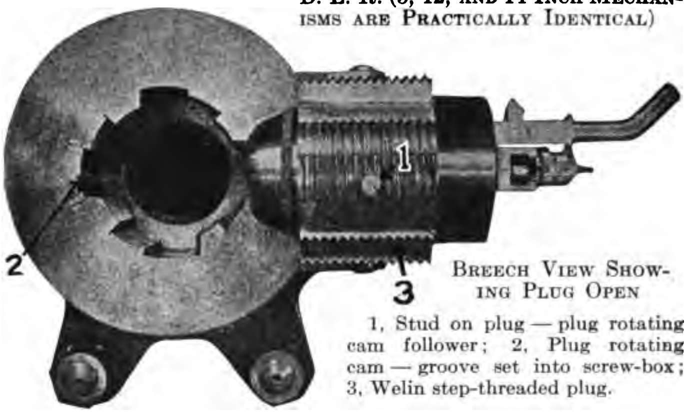
The lower end of the operating-lever is fixed to the end of a **crank-shaft** which extends through the center of the carrier arm, from the operating-lever to the plug. On the plug end of this crank-shaft there is what is called an overhung pin or crank, which projects into a part of the plug, extending parallel to the crank-shaft itself, but suspended down at a distance of several inches from the crank-shaft.

This **overhung pin operates in a small bearing in the rear face of the plug itself, called a crosshead.**

When the operating-lever is moved to the rear and downward in unlocking the plug, the crank-shaft in the carrier revolves through an angle of approximately 133°. The crank-shaft causes the overhung pin on its end to describe an arc of a circle about the crank-shaft as an axis. The pin, in describing this arc, works in the crosshead bearing on the rear face of the plug which transmits the motion of the pin to the plug and revolves it through an arc of 33 degrees, unlocking it from the threads of the screw-box.

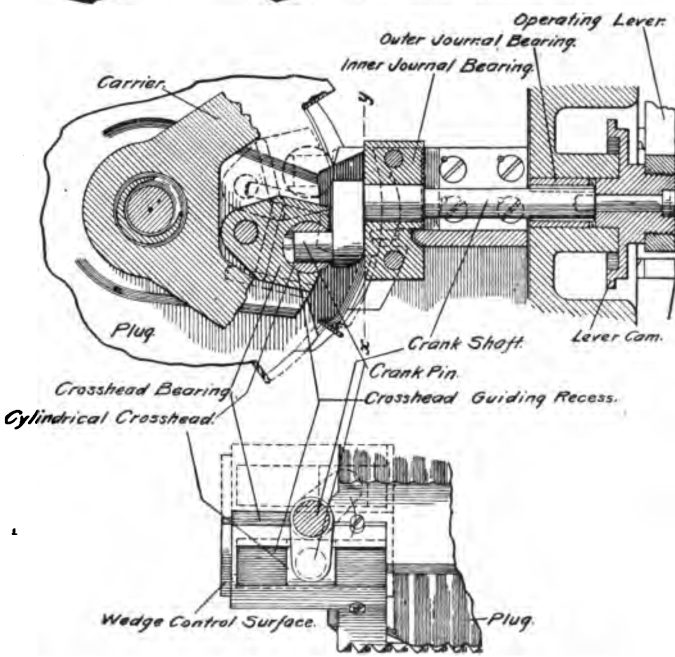
The **PLUG–ROTATING CAM** now performs its function. It consists of a **curved or cam-slot cut into the left side of the**

SMITH-ASBURY BREECH-OPERATING MECHANISM SHOWING 5-INCH B. L. R. (5, 12, AND 14-INCH MECHANISMS ARE PRACTICALLY IDENTICAL)



BREECH VIEW SHOWING PLUG OPEN

1, Stud on plug — plug rotating cam follower; 2, Plug rotating cam — groove set into screw-box; 3, Welin step-threaded plug.



Section on x–y.

CROSS SECTION SHOWING PLUG-ROTATING GEAR

Note details of mechanism inside of carrier arm and at breech face of plug.

screw-box, in the blank between two threaded sections. Actually, the slot is cut into a hardened steel plate and the whole plate is fitted into the screw-box. **To match and fit into the cam-slot** there is a projection in the nature of a small stud, called the **cam-follower,** from the threaded section of greatest diameter on the plug, next to the blank containing the cam-slot. The slot in its forward part moves around inside the screw-box following the pitch of the threads. It then describes a curve in its blank section and extends out straight to the breech face. When the plug is closed and locked, the stud rests in the cam-slot. As the plug is revolved in unlocking, the stud keeps in the cam-slot, at first following the pitch of the plug threads. When the plug has revolved through an angle of about 26 degrees, the plug is unlocked from the screw-box threads. During the remainder of the plug revolution to 33 degrees the stud is guided in the slot as it curves gradually to a position extending toward the breech face, or in a line parallel to the gun axis. **During the remaining 7 degrees of its rotation, then, the motion of the plug is gradually changed without shock from one of rotation to translation, the translation movement to the rear, started by the cam, being taken up and carried through by swinging the operating lever to the right in a horizontal plane.** The action of the cam and follower is just the reverse in closing the breech.

The advantages of the plug-rotating cam are most marked during the act of closing the breech, when, by checking gradually the velocity of the swinging parts, it serves to avoid the objectionable slamming and rebounding of the carrier by utilizing and absorbing the energy of the swinging parts, imparting a rotary motion to the plug taken up and continued by the operating lever.

The **CONTROL ARC AND STOP** serves to take up the shock at the end of the swing of the plug to the rear and right when the breech is opened.

When the plug has swung through 90° to the right, further motion to the right is prevented by a buffer which takes up the shock. This buffer consists of a cylinder with a

plunger, surrounded by a set of three spiral springs. It is bolted to the gun by a yoke just below the hinge of the carrier.

The **control-arc** engages a threaded section of the plug when the breech is open, preventing any rotation of the plug when it is not in the screw-box. Without some such device the plug might revolve a small degree while out of the screw-box and thus make it impossible to close the plug without an appreciable delay.

The **SALVO-LATCH** is pivoted on a pin on the right-hand side of the carrier arm. During recoil of the gun, the inertia of the salvo-latch gives it a pendulum motion about its supporting pin. And during this swinging motion the latch locking the operating-handle is released. **As the salvo-latch is not disengaged automatically except upon discharge and recoil of the gun it gives warning of miss-fires or hangfires which might otherwise have passed unnoticed when a number of guns are being fired in salvo, or together.** In such a case the breech can be opened only by tripping the salvo-latch by hand.

The **GAS-EJECTOR** is of standard design, except that only 4 air holes lead to the screw-box. The valve is automatically opened by the rotation of the plug in opening and is closed by hand after the breech is opened and the bore cleared of gases.

This gun is provided with a **screw-box liner.** The rear end of the gun jacket being bored out and threaded to receive the liner.

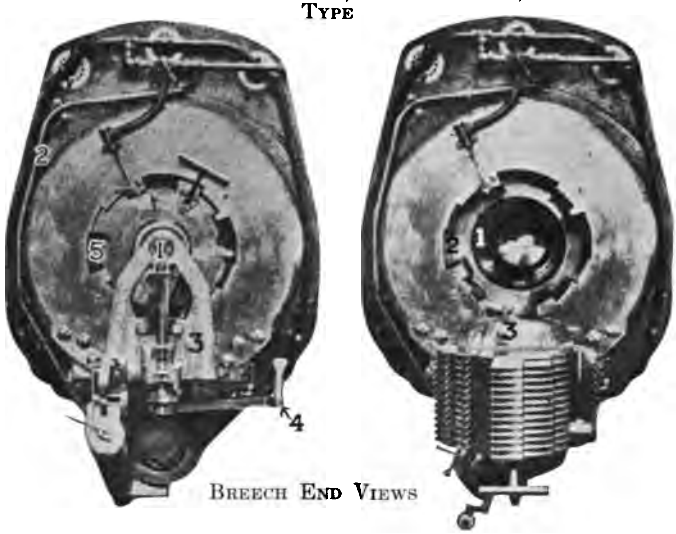
The **FIRING MECHANISM** is of the very latest design. **This mechanism is of the self-feeding, automatic type.**

The **firing-lock receiver** is secured to the after end of the mushroom shank by means of a bayonet joint and is so fitted as to prevent any movement of the lock in rotation.

The receiver carries a **magazine which holds two primers at one time. Opening and closing the breech mechanism actuates the firing-lock, causing it to eject the empty primer and load a fresh one.**

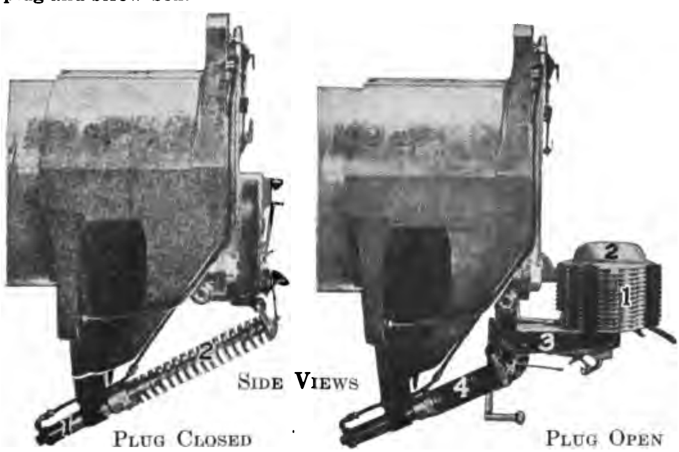
The firing mechanism is given its entire movement by

Breech Mechanism — 14-Inch, 3-Gun Turret, Drop Plug Type



Plug Closed and Locked. 1, Firing mechanism; 2, Compressed air supply pipe; 3, Carrier; 4, Operating handle; 5, Note spaces between blank sections of plug and screw-box.

Plug Open. 1, Powder chamber; 2, Screw-box; 3, Mushroom head of plug.



1, Compressed air closing cylinder; 2, Spring surrounding piston of air cylinder.

1, Plug with Welin stepped threads; 2, Mushroom head; 3, Carrier; 4, Note breech closing spring at compression.

means of a cam attached to the operating-lever of the breech mechanism.

After the gun is fired, a new primer is placed in the firing-lock magazine over the one to be loaded. When the breech is opened, the fired or empty primer case is ejected. When it is closed and fully locked, a new primer is brought down into the primer seat. The **firing-pin** seated in the **firing-lock wedge** is prevented from advancing beyond the face of the wedge by a **safety-arm** which maintains its position until the plug is fully rotated closed. This forms an effectual **safety device.**

In case of a missfire, the faulty primer may be ejected, and the second primer in the magazine be inserted in its place by hand, by pulling the firing-lock operating-handle outward as far as it will go and then pushing it back in place, the breech remaining closed.

The firing mechanism is also fitted with the standard system of **connections and attachments for electrical firing.**

14- AND 16-INCH BREECH MECHANISMS FOR GUNS USED IN THREE-GUN TURRETS (DROP PLUGS)

Breech Mechanisms for the 14-inch and 16-inch guns which are mounted in the three-gun turrets of our latest super-dreadnoughts are essentially the same as the 12-inch Mark IX Breech just described — the Naval Gun Factory design or Smith-Asbury Type.

The principal difference is in the plug, which drops back and down to the rear of the screw-box, instead of swinging to the right. This is made necessary by the methods of mounting the three guns in one gun-slide.

A **COUNTER-BALANCE SPRING** and a **COMPRESSED AIR-CLOSING CYLINDER** are provided with each breech to facilitate opening and closing the plug.

In opening the breech the operating-lever is swung, first to the rear, and then to the left either by hand or by means of a lanyard. This rotates the crank-shaft in the carrier arm which operates to rotate and unlock the plug as de-

scribed for the 12-inch Breech Mechanism. The plug then swings open to the rear and downward through an arc of 90° by means of the plug handle and its own weight. **When open, the carrier and plug are supported by a counter-balance spring which serves also as a buffer in easing the drop of the plug when opening.**

The **CLOSING CYLINDER** is located directly under the counter-balance spring, the piston or spring-rod of the closing cylinder extending up through the counter-balance spring. To close the breech, compressed air is admitted to the closing cylinder by opening the valve by hand. The air pressure on the piston is transmitted to the spring-rod and by it to mechanism which closes the breech and rotates the plug closed. When the plug is locked, the air in the cylinder is automatically shut off by opening a by-pass valve to the atmosphere.

In all other respects the mechanism is identical with that described as the twelve-inch, Mark IX.

CHAPTER VI

BREECH MECHANISMS FOR BROADSIDE AND MINOR-CALIBER GUNS

5-INCH RAPID-FIRE AND B. L. R. TYPES — 3- AND 4-INCH ECCENTRIC PLUG R. F. TYPES — HOTCHKISS SEMI-AUTOMATIC 1, 3, AND 6-POUNDERS

THERE are a great number of various types of breech mechanisms for guns of medium and minor calibers in use in the Service today, and no effort will be made to describe all of these. Only the breech mechanisms of the latest and most approved designs now being manufactured and fitted to guns will be covered in any detail. Other types of breeches will only be covered sufficiently to make clear the principle of action of the mechanism.

The five-inch gun is considered and has been generally adopted as the most desirable size for a broadside gun and will be treated at greater length than breeches of other calibers.

5-INCH BREECH MECHANISM FOR B. L. R.'S, MARK VII — NAVAL GUN FACTORY DESIGN

This breech is the latest and most approved type for use in breech-loading rifles or powder-bag guns of 5-inch caliber, and is fitted to such guns on our most modern battleships.

The mechanism is almost identical with that described for the 12-inch Mark IX, turret gun breech, and frequent reference will be made to the description of the operation of that breech mechanism as we go along.

The **BREECH-BLOCK OR PLUG** is of the Welin or stepped-screw type, and is slotted to form 12 sections — 8 threaded steps and 4 blanks in 4 groups, the blanks being wider than the threaded steps to permit the action of the plug-rotating mechanism.

A **screw-box liner** is provided inside the rear end of the gun jacket, being screwed into its position inside the jacket. The inside of the liner forms the screw-box and is threaded and blanked similarly to the plug.

The DE BANGE GAS-CHECK SYSTEM is fitted to this breech, and is of the standard type, consisting of **mushroom head and stem in one piece, split rings, pad obturator, mushroom spring, and nut.** The **primer vent** extends through the stem and mushroom head, the breech end of the stem being recessed to form the **primer seat.**

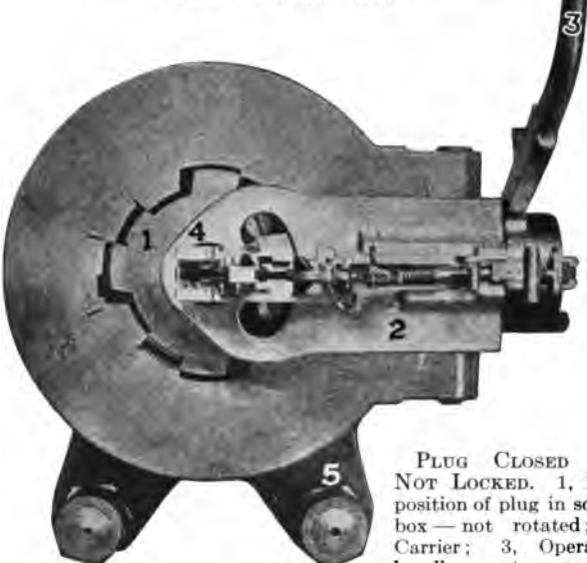
The **OPERATING MECHANISM** consists of the following principal parts:

Carrier
Operating-lever or crank
Operating-lever crank-shaft
Plug-rotating mechanism

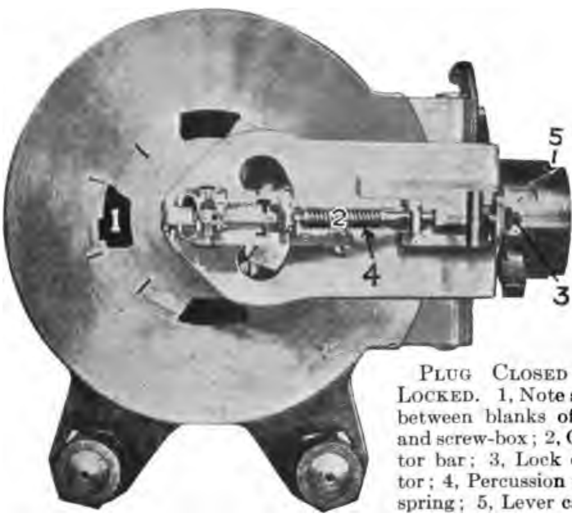
The **carrier** serves to carry the plug, when the plug is not seated in the screw-box. It is a heavy steel arm projecting across the right side of the breech face of the gun. One end of the carrier is hinged to the right side of the gun breech by a **hinge-pin.** The other end is fitted with a **hub**, and on this hub the plug is seated or journaled by a tight joint, the hub and its plug projecting forward from the carrier. When the breech is opened, the whole carrier, with the plug, swings on the carrier hinge-pin clear of the breech of the gun.

The **operating-lever** is on the right side of the gun. When the plug is closed and locked, this lever inclines upward and toward the muzzle at an angle of about 45°. **To open the breech the handle is first swung to the rear and downward in a vertical plane.** This first rotates and unlocks the plug from the screw-box threads. **The handle is now swung to the right in a horizontal plane** through an angle of 90°. This swings the carrier with its hub and the plug

5-INCH B. L. R. (SMITH-ASBURY BREECH)
VIEW OF BREECH FACE



PLUG CLOSED BUT NOT LOCKED. 1, Note position of plug in screw-box — not rotated; 2, Carrier; 3, Operating handle — note position for plug not locked; 4, Hub of carrier; 5, Lugs for piston rods.



PLUG CLOSED AND LOCKED. 1, Note spaces between blanks of plug and screw-box; 2, Operator bar; 3, Lock operator; 4, Percussion firing-spring; 5, Lever cam.

to the right and clear of the breech. Reverse motion of the operating-handle closes the breech.

The **plug-rotating mechanism** consists principally of the **operating-lever crank-shaft** with its **overhung pin** and the **plug crosshead** in which the pin operates. Also the **plug-rotating cam** which changes the rotary motion of the plug in unlocking to a motion of translation, and vice versa in locking the plug.

The operation of this plug-rotating mechanism has been described in detail for the 12-inch Mark IX, Main battery gun breech. Its operation in this 5-inch breech is identical.

An operating-lever guide and stop are fitted to the breech to take the place of the **control-arc and stop** on the **12-inch turret gun.** This serves to limit the swing of the plug and its carrier to the right when the breech is opened, and to prevent any rotation of the plug in its carrier when it is out of the screw-box.

The **SALVO-LATCH** is pivoted on a pin on the right-hand side of the carrier arm. It is really an **operating-lever latch,** as it serves to lock the operating-lever when the breech is closed and prevents any motion of the operating-lever toward opening the plug until the gun has recoiled after firing and thus tripped the latch. For drill purposes the latch is tripped by hand.

The **GAS-EJECTOR** is of standard design, four air holes leading to the screw-box from a $\frac{3}{4}$-inch copper pipe leading around the breech face of the gun.

The **FIRING MECHANISM** is of the very latest design. **This mechanism is of the self-feeding automatic type.**

The receiver of the firing-lock is secured to the after end of the mushroom shank by means of a bayonet joint and is so fitted as to prevent any movement of the firing-lock in rotation.

The receiver carries a **magazine which holds two primers at one time.** Opening and closing the breech actuates the firing-lock, causing it to eject the fired, empty primer, and load the fresh one.

The firing mechanism is given its entire movement by

means of a small cam attached to the operating-lever of the breech mechanism.

After the gun has been fired, a new primer is placed in the firing-lock magazine, over the one to be next loaded. When the breech is opened, the fired or empty primer case is ejected. When the breech is again closed and fully locked, a new primer is brought down out of the magazine into the primer seat. The **firing-pin** is seated in the **firing-lock wedge** and is prevented from advancing beyond the face of the wedge by a **safety-arm** which keeps its position over the wedge until the plug is fully rotated closed. This forms an effectual safety device.

In the case of a missfire, the faulty primer may be ejected, and the second primer in the magazine be inserted in its place by hand, by pulling the firing-lock operating-handle outward as far as it will go and then pushing it back in place, **the breech remaining closed.**

The breech is equipped for both percussion and electrical firing, the standard type of electrical connections and attachments being fitted.

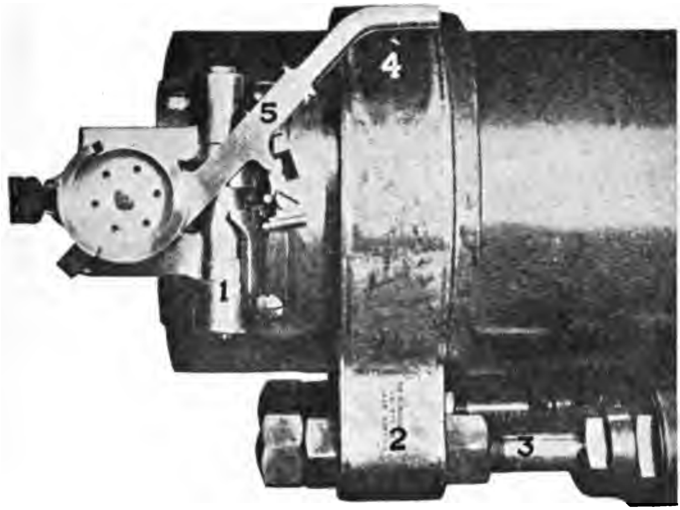
4-INCH BREECH MECHANISM MARK VIII — ECCENTRIC-PLUG TYPE FOR RAPID-FIRE GUNS

This 4-inch breech mechanism is designed for use with rapid-fire, or cartridge-case guns. **It employs an eccentric plug,** which is one of its principal features. It is described here principally because **it is the most modern type of 4-inch mechanism that we have,** and secondly, **because in its operation it is essentially the same as the 5-inch mechanism previously described.**

The **BREECH–PLUG** is of the Welin stepped-screw type, having three blanks and six threaded steps. A **screw-box liner** is screwed into the rear end of the gun jacket. **This screw-box liner is bored out eccentrically or off-center so that the true center of the screw-box which receives the plug is not in line with the axis of the bore of the gun.**

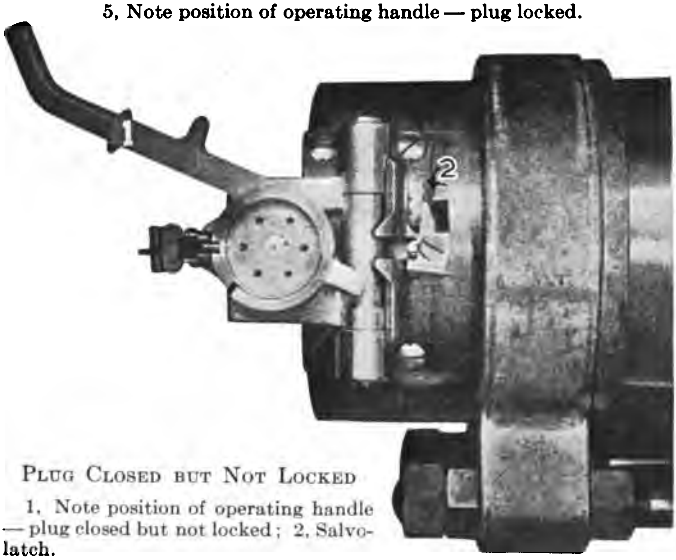
The **OPERATING MECHANISM** includes the following

5-INCH B. L. R. (SMITH-ASBURY BREECH).
SIDE VIEW OF BREECH-OPERATING MECHANISM



PLUG CLOSED AND LOCKED

1, Carrier hinge pin; 2, Lug for piston rod; 3, Piston rod; 4, Yoke; 5, Note position of operating handle — plug locked.



PLUG CLOSED BUT NOT LOCKED

1, Note position of operating handle — plug closed but not locked; 2, Salvo-latch.

principal parts, **all of which are identical in design, construction, and operation with those of the 5-inch Breech** just described:

The **carrier, operating-lever, operating-lever crank-shaft,** and the **plug-rotating mechanism, including** the **overhung pin** of the **operating-lever crank-shaft** and the **cross-head on the plug in which it operates,** as well as the **plug-rotating cam.**

The only additional part is the **EXTRACTOR which we, of course, find only on rapid-fire guns.** This extractor consists of an arm extending through the right side of the gun and coming out into the inside of the screw-box. The screw-box end is in the shape of a lug which is seated between the rim of the base of the cartridge case, and the gun bore, when the gun is loaded. The other end of the extractor is fashioned into a cam, which rests against the right side of the carrier arm when the breech is closed. The extractor operates on a hinge-pin which is behind the carrier hinge-pin and parallel to it in a vertical plane. When the carrier swings out as the breech is opened, it works on the cam on the extractor. The extractor swings on its hinge and the inner lug seated under the cartridge rim is forced out toward the breech and carries or extracts the empty cartridge case out to the rear.

A SALVO–LATCH is fitted to the gun, being suspended from a pin on the right side of the carrier arm. It is of the usual type in construction and operation.

The **FIRING MECHANISM** is distinctive. No firing-lock is provided, these being used only on powder bag guns, where it is necessary to carry a primer to explode the charge.

Cartridge-case ammunition carries the primer fixed in the base of the cartridge. **Rapid-fire gun breeches are fitted with firing-pins which operate back and forth through the center of the breech-plug** and are housed in the center of the breech-plug.

As stated before, **the screw-box is seated eccentrically in the screw-box liner and its center is therefore out of line with the center of the gun bore.**

The firing-pin is also located eccentrically or off the center of the breech-plug.

The cartridge-case and the primer fixed in its base is, of course, in line with the center of the gun bore.

When the plug is unlocked from the threads of the screw-box, the firing-pin in the plug is not in line with the center of the gun bore, nor the primer, due to the eccentricity of screw-box and firing-pin. **However, as the plug rotates locked, the firing-pin approaches the primer, until, when the plug is rotated fully closed, the firing-pin, by the double eccentricity, one of which offsets the other, is directly in the rear of the primer, ready for firing.**

As the breech is opened, the firing-pin is automatically cocked, and when the plug is again fully closed, the gun is ready to fire.

This breech is equipped only for percussion firing, although as a general rule all guns above 3-inch fire by percussion or electricity.

5-INCH BREECH MECHANISM, MARK VI, BETHLEHEM TYPE FOR RAPID-FIRE GUNS

This mechanism is the design of the Bethlehem Steel Co. and **is the one used on most of the latest type of 5-inch guns using fixed or cartridge-case ammunition.** Such guns are mounted in the broadside batteries of many of our new dreadnoughts.

The **BREECH–PLUG** is divided into three groups, each containing two threaded and one blank sections. It has one unusual feature in that the threads have no pitch, being merely interrupted parallel collars around the circumference of the plug. They therefore impart to the plug no motion to the rear, or of withdrawal during rotation. This withdrawal motion is started by the pitch of the threads by which the plug is attached to the hub of the carrier arm, and is taken up and continued by the swinging of the carrier, with the plug, away from the breech face of the gun. **It is claimed that this system eliminates friction during rotation of the plug.**

The **OPERATING-GEAR** is made up of the following most essential parts:

Carrier
Operating-lever
Plug-rotating link
Extractor

The **carrier** is, generally speaking, of the usual type, a heavy arm projecting across the right side of the breech face, being hinged to the gun on one end and carrying a hub on the other end to which the plug is secured.

The **operating-lever** extends straight across the breech face of the gun in the rear of the carrier arm. It is pivoted by means of a vertical hinge-pin to the carrier. **One operation of the lever is all that is required to open the breech. This operation consists in swinging the operating-lever to the rear and right in a horizontal plane.** This first rotates the plug and then swings carrier and plug clear of the breech.

The **plug-rotating link** consists of a small arm or link between the operating-lever and the plug, being joined at each end by a universal joint. It operates to unlock the plug from the screw-box threads during the first part of the motion of the operating-lever to the rear.

The **extractor** is located in a recess cut into the right side of the gun, and projects into the screw-box. On its inner end it carries a lug or nib which fits under the rim of the cartridge-case when the gun is loaded.

The general scheme of operation of the mechanism is briefly as follows:

In opening the breech, the first movement of the operating-lever causes the plug to revolve to the left by the action of the plug-rotating link, until the plug is disengaged from the screw-box threads. The remaining motion of the operating-lever to the right causes the carrier to swing about its hinge-pin, carrying the plug with it. A device locks the plug against rotary motion while it is out of the screw-box. At the end of the swinging motion of the carrier arm the outer end of the extractor is operated by being pressed forward. **This causes the extractor to turn on its vertical hinge, forc-**

ing the inner nib under the cartridge rim to the rear, ejecting the empty cartridge-case sharply.

The **FIRING MECHANISM** provides for both percussion and electrical firing. The details need not be gone into. As in all rapid-fire gun-firing mechanisms, a firing-pin is located in the center of the plug and in this case is concentric or dead on the center. This firing-pin is seated in a sleeve and is insulated from the rest of the plug to permit of the current passing through it to the primer in electrical firing.

The **gun cannot be fired until the breech is fully closed,** because neither the electric nor the percussion firing mechanism is fully connected until the breech is closed.

5, 6, 7-INCH BREECH MECHANISMS, MARK I, FOR BREECH-LOADING RIFLES

Breech mechanisms for guns of these types are essentially the same for 5-inch, 6-inch, and 7-inch calibers, except in minor details. The 7-inch gun is found only in the broadside batteries of pre-dreadnoughts of U. S. S. *Connecticut* and *New Hampshire* class. The 5- and 6-inch guns are found in the broadside batteries of other battleships of the pre-dreadnought type.

No attempt will be made to describe the mechanism in detail. From a study of the description of the breeches already covered and a general knowledge of breech mechanisms, this type will be readily understood with a little practical experience in its use and operation.

The **PLUG** is of the Welin, stepped-thread type, and is supported when out of the screw-box by a hub on the carrier arm.

The **DE BANGE GAS CHECK** is provided and is of standard design.

OPERATING–GEAR. The **carrier arm** is of bronze and extends across the right side of the breech face of the gun.

The **operating-lever** also extends straight across the breech face in the rear of the carrier, being hinged to the carrier by a vertical hinge-pin on the right side.

The **plug-rotating link** connects the operating-lever to the

plug and serves to unlock the plug during the first part of the motion of the lever in opening the breech.

The **OPERATION OF THE BREECH** in brief is effected as follows:

In opening the breech the operating-handle is swung to the rear and right in a horizontal plane by one motion of the arm. During the first part of the motion of the lever the plug-rotating link is operated to unlock the plug from the screw-box threads; continued movement of the operating-lever to the right swings carrier and plug clear of the breech.

At the end of the carrier arm is a small buffer which absorbs the shock of the closure of the breech. The cushioning effect of the buffer is regulated by a small air-valve.

The **FIRING MECHANISM** permits either of percussion or electrical firing.

The **firing-lock** is secured to the end of the mushroom stem and includes the usual parts.

The **gun cannot be fired prematurely** as the firing-pin is not in contact with the primer until the breech-block is closed and locked.

A **SALVO–LATCH** is provided and is hung from the lower part of the breech face. It operates in the usual manner.

A **GAS–EJECTOR** of standard type is fitted to the breech.

MINOR-CALIBER BREECH MECHANISMS — 3-INCH BREECHES

The only three-inch breech mechanisms now being manufactured for use in our service are of the **semi-automatic type**; that is, a breech wherein the energy of recoil and counter-recoil are utilized to perform all the operations of ejecting the fired cartridge-case, and opening and closing the breech, leaving for the operator only the placing in position of the new cartridge.

3-INCH SEMI-AUTOMATIC BREECH, MARK V

This is the only S. A. 3-inch in use at the present time. It is referred to as the **Driggs-Seabury 3-inch.**

The breech-plug consists of a square- or rectangular-shaped block containing the firing mechanism and which drops straight down in opening the breech.

The general principle of the mechanism and its operation are very similar to the Hotchkiss 1, 3, and 6-pounder S. A. Guns, which are later described in detail.

OTHER 3-INCH MECHANISMS IN USE are the **Mark** III, which is the oldest type, having an ordinary interrupted-screw plug of the French type and an operating arm and carrier extending across the right side of the breech face. The mechanism is somewhat similar to the breech mechanisms for 5, 6, and 7-inch guns, Mark I, except on a smaller scale and employing a system of gears for plug rotation rather than a plug-rotating link. It also differs, of course, in that it is designed for a rapid-fire gun.

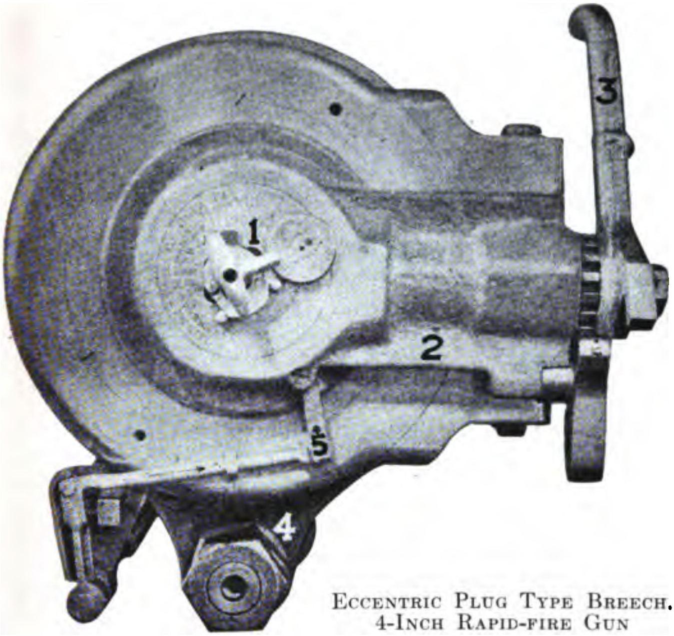
Another type of 3-inch breech in wide use is the Mark VI, which employs an eccentric plug and an operating-lever which requires motion in two directions — first, to the rear and down, and secondly, to the right, to open the breech. In these, and in practically all other respects, **this 3-inch breech is similar to the 4-inch eccentric plug breech, Mark** VIII, which has been described in detail.

HOTCHKISS SEMI-AUTOMATIC BREECH FOR 1, 3, AND 6-POUNDERS

The general principle of operation of the Hotchkiss sliding wedge breech mechanism has already been described in connection with the discussion of various types of breech mechanisms generally.

Practically, all 1, 3, and 6-pounders now being manufactured and issued to the Service for use are of the semi-automatic type, and of "Hotchkiss" design, so far as the breeches are concerned, so that a description of this mechanism will suffice for most of the type.

The following detailed description applies equally to 1, 3, and 6-pounders. Different "marks" and "modifications"



Eccentric Plug Type Breech.
4-Inch Rapid-fire Gun

1, Note eccentricity of firing pin in plug; 2, Carrier; 3, Operating handle; 4, One lug for piston rod (one recoil cylinder); 5, Firing lever (percussion firing only).

Semi-Automatic Breech.
3-Pounder Hotchkiss Showing
Breech Open

1, Operating handle; 2, Breech block dropped down — breech open; 3, Thrust rod; 4, Breech closing spring; 5, Shoulder bar; 6, Breech housing; 7, Cocking toe — cocks firing mechanism when breech is opened.

vary, of course, in certain of the mechanical details of the semi-automatic mechanism and in its operation.

The **BREECH-BLOCK** is a rectangular block of steel with an approximately square cross-section. The steel is cut away in several places to allow for the proper operation of the mechanism and also to provide for the housing inside of it, of certain parts, particularly the firing mechanism. **The breech-block rests and operates up and down in a square-shaped breech-housing,** cut away at the after end to permit the cartridge being loaded through it.

The **OPERATING-LEVER** resembles a small hand crank. It sets in a joint, usually in the right, but sometimes in the left, cheek of the breech-housing of the gun. On its inner end it carries a stud which extends through the side of the breech-housing, engaging and operating in a groove in the side of the breech-block. **When the operating-lever is moved to the rear, this stud operates in the groove of the block, causing it to drop, thus opening the breech. Moving the lever up and forward raises the block and closes the breech.**

A **stop-bolt** catches and stops the block when it has dropped down sufficiently far to expose the bore of the gun, preparatory to loading.

The first part of the motion of the operating-lever to the rear in opening the breech serves to cock the firing-pin, which is housed in the breech-block. The remainder of the motion of the operating-lever to the rear causes the plug or breech-block to drop, exposing the bore. **Thus, the breech-block remains fully closed until the firing-pin is cocked.** This is effected by the manner of cutting the groove in the side of the breech-block. **The firing-pin is cocked** by a cam device on the operating-lever which engages the cocking-toe or cocking-piece of the gun, during the first part of the motion of the operating-lever to the rear.

THE SEMI-AUTOMATIC FEATURE OPERATES AS FOLLOWS:

When the gun is fired, it recoils and comes to the rear in its slide. **A breech-closing spring** is fitted to the gun on

the same side of the breech as the operating-handle. **One end of this breech-closing spring is attached to the operating handle, the other end is made fast to a thrust rod pivoted on the slide of the gun mount. When the gun recoils to the rear, this breech-closing spring is stretched out or put at a tension,** inasmuch as its one end is attached to the slide and is fixed during recoil, while the other end is attached to the operating-handle, which goes back in recoil with the gun. **When the gun overcomes its tendency to recoil and moves back in counter-recoil to its "in battery" position, the "tension" in the breech-closing spring exerts a pull on the thrust rod pivoted on the gun-slide and causes it to come back to the rear.** A stud on the end of the thrust rod is thus placed directly in the path of the operating handle of the breech as the gun comes back "in battery." **As the gun comes back, then, this stud on the thrust rod engages a roller bearing on the arm of the operating-lever, and as the gun continues to come back in counter-recoil, the operating-lever is forced to the rear, opening the breech in exactly the same manner as if the lever had been operated by hand.**

An **EXTRACTOR** operates longitudinally in a slot in the inside of the breech-housing and on the side opposite to that on which the operating lever is mounted. Motion is given to the extractor usually by a stud which is attached to it and which operates in a groove in the side of the breech-block. The rear face of the breech-block is inclined slightly downward and to the rear, so that the whole block moves slightly to the rear when it drops. **This enables the extractor, the rim of which is seated under the rim of the cartridge-case, to start the extraction of the empty cartridge-case slowly. As the block drops, the case is thrown sharply out of the gun.** Now then, when the gun comes back "in battery" after recoil, the thrust rod is interposed in the path of the operating-handle and forces it to the rear. **The breech is opened automatically and the extractor ejects the empty shell, both operations being effected at the end of counter-recoil.**

In this open position, the breech-block is held down by the extractor, until a new shell is loaded. The new shell is shoved smartly into the bore of the gun. As it seats itself, it pushes the extractor forward and the lug of the extractor is forced into position between the bore of the gun and the rim of the cartridge. **As the extractor moves forward, the breech-block is released, and the breech-closing spring, which is at a slight tension,** due to the operating-handle being back, or in the "open" position, **operates to pull the operating-handle forward, closing the breech** in the same manner as if the handle had been operated by hand.

The gun is now ready for the next firing. The **firing-key** is usually located in a pistol grip in the right hand of the gun trainer and pointer.

The **firing mechanism** is simple, consisting merely of an ordinary type of hammer pivoted in the breech-block. Only percussion firing is, of course, provided.

For the first shot, the breech must be opened by hand. From then on, the operation of the gun is semi-automatic, as described in the foregoing.

CHAPTER VII

GAS-EXPELLING DEVICE

A **GAS-EXPELLING DEVICE, usually termed in practice a gas-ejector, is a device the purpose of which is to blow out through the muzzle of the gun after each firing, by means of compressed air, the inflammable gases remaining from the last powder charge; also any burning particles remaining in the bore from the preceding powder charge.**

FLAREBACKS: After a gun has been fired, **especially if firing directly into the wind**, an inflammable gas from the smokeless powder often either remains in the bore of the gun or is blown back into the bore by the wind. When the breech-plug is suddenly opened, this gas is sometimes ignited by the sudden admission of fresh air in connection with smoldering or burning particles that may be in the bore from the last charge. **This is called a flareback, the flame flaring back into the faces of the gun crew and endangering any powder in the vicinity, ready for subsequent loadings.**

Gas-ejectors are fitted only to B. L. R.'s or separate ammunition guns. All B. L. R.'s should be so fitted.

In rapid-fire guns, the empty cartridge-case remains in the gun sufficiently long to overcome the possibility of "Flare-backs."

An **AIR-COMPRESSOR,** located centrally on the ship, compresses air from the atmosphere and supplies it through a system of piping to **an accumulator at each gun.** The **ACCUMULATOR** is connected to the **gas-ejector valve,** mounted on the breech face of the gun, by means of a flexible length of pipe or hose so arranged as not to interfere

with the training or elevation of the gun and long enough not to be broken by the gun's recoil after firing. **Compressed air is supplied to this valve at a pressure of 150 pounds.** Through the valve, when the valve-latch is tripped, the air passes through a circular pipe, surrounding the breech face of the gun, and thence through several holes, usually six, leading to the screw-box and opening into it just to the rear of the gun bore.

As the breech-plug is opened, after a firing, the edge of the plug trips a catch or cam plate on the bottom of the ejector-valve. This opens the valve and compressed air is forced through the bore during the time that the breech is being opened. **By the time it is open, the bore is clear.** It is the duty of one member of the gun crew to look through the bore when the breech is open, calling out " bore clear." It is also the duty of a member of the gun crew to trip the latch of the valve by hand when bore is clear to stop passage of air.

During any firing air pressure is kept on up to the ejector-valve on the breech face of the gun.

The time of ejection of the gases and the time of passage of compressed air through the gun bore starts either as the plug commences to revolve in unlocking or as it starts its motion of withdrawal to the rear, this varying according to the type of ejector fitted to the gun.

The holes projecting into the screw-box vary in number from three to eight, depending on the caliber and mark and modification of the gun. These holes are slightly turned at their inner ends, so that the compressed air travels down the bore spirally, following, in a manner, the twist of the rifling.

CHAPTER VIII

ELECTRICAL FIRING CONNECTIONS AND ATTACHMENTS FOR BROADSIDE AND MAIN BATTERY GUNS

ELECTRIC SIGHT-LIGHTING EQUIPMENT — FIRING MECHANISMS AND FIRING ATTACHMENTS

THE **FIRING MECHANISM** of a gun is essentially a part of the breech mechanism and has already been described in connection with breech mechanisms.

The term **firing mechanism** is used to designate that part of the breech mechanism which **directly explodes the primer and thus fires the gun.** A mechanical contrivance or device called a **firing lock** comprises the firing mechanism on a breech-loading rifle or separate-ammunition gun.

The **FIRING LOCK** from its very name makes known its function, **which is to lock the primer in position in rear of the powder charge, and to fire it, thus exploding the powder charge and firing the gun.** The firing lock consists essentially of a **receiver, a device for locking the primer in place**; an **extractor** for ejecting the empty primer case after it is fired; **a firing-bolt, with a spring and a sear** for holding the firing-bolt cocked; and a **trigger** to release the sear, and to which the percussion firing lanyard is secured.

The **receiver of the firing lock** screws on to the **rear** of the mushroom shank of the breech-plug and contains a **wedge,** which is so constructed that it unmasks the primer seat for the insertion of the primer and closes over the new primer when seated, locking it in position ready for firing. This

wedge also contains the firing-pin and the firing-pin spring; when the wedge is closed over or in the rear of a live primer, the firing-pin is thus immediately in the rear of the fulminate of mercury cap of the primer. In percussion firing, the firing-bolt, when released by the sear on pressure on the trigger, springs forward and strikes the firing-pin, which in turn strikes the primer percussion cap and thus fires the primer and the gun.

Guns are fired by percussion and by electricity. Percussion primers are used for rapid-fire guns of 4-inch caliber and smaller. Guns of larger caliber than 4-inch use combination primers that may be fired either by percussion or by electricity. For large guns, electric firing is considered far preferable, percussion firing being used only as an alternative.

PERCUSSION FIRING MECHANISM for a Breech-Loading Rifle, as already described, is included in the firing lock. Generally speaking, it consists of a firing-pin surrounded by a spiral spring, the firing-pin having an axial movement within the lock or within the firing mechanism and in the rear of the primer. The firing-pin is usually cocked automatically by the opening of the breech mechanism, or it may be cocked by hand. A percussion firing mechanism can be simply defined as one in which the blow or impact of a hammer or firing-pin explodes a cap in a primer.

In the case of Rapid-Fire Guns, a firing lock is not used, but the percussion firing mechanism includes a firing-pin and bolt, both centered in the breech-plug. When the gun is fired, the point of the firing-pin projects or jumps forward from its housing in the plug, past the forward face of the plug, striking and exploding the percussion cap of the primer, which is located in the base of the cartridge-case in the gun chamber; rapid-fire guns using fixed ammunition.

ELECTRIC FIRING MECHANISM is also included largely in the firing lock of a Breech-Loading Rifle. In this mechanism, the firing-pin is insulated from the rest of the

firing lock which surrounds it, the passage of the electric current being confined to it and cut off from the rest of the mechanism, **and is suitably connected by electric terminals and wires to a source of electricity.** When a proper connection has been made, the electric current passes through the firing-pin and primer case, heats a fine wire or bridge inside the primer to a sufficiently high temperature, and this explodes the primer charge of powder, usually through the medium of a wisp of dry gun-cotton wound around the wire bridge.

FIRING ATTACHMENTS

FIRING ATTACHMENTS include all devices or appliances that are used to put the firing mechanism in operation. These appliances include **firing keys, the electric firing battery, wires, terminals, etc.**

The **firing mechanism** includes only the mechanism which directly explodes the primer and fires the gun. It is a part of the breech mechanism.

The **firing attachments** form neither a part of the firing mechanism nor the breech mechanism.

The two terms should not be confused.

ELECTRIC FIRING ATTACHMENTS AND CONNECTIONS

For large guns electric firing is generally considered preferable, percussion firing being used only as an alternative. Electric firing shortens the firing interval, or the time that elapses between the instant the gun pointer wills to fire and the instant the projectile leaves the muzzle of the gun. The electric current travels more quickly and can be set in action quicker than the mechanical system of percussion firing.

CURRENT FOR ELECTRICAL FIRING is supplied either by storage batteries or by motor generator from the ship's interior communication system.

The **firing mechanism is so connected up electrically that either source of current may be used, simply by operating a switch attached to the gun mount.** As a general rule, the

current is taken from the motor generator, the storage battery being used as an auxiliary source of supply, inasmuch as the batteries run down and have to be recharged.

Storage batteries are carried in battery-boxes attached to the gun mount. The batteries can be recharged from the ship's circuits. The batteries carry stored electricity and should always be fully charged, inasmuch as in case of the cutting off of the ship's electrical supply during an engagement, the guns can continue to be fired electrically by current from the storage batteries.

Motor-generator current is taken from the ship's interior communication system. **Motor generators** are electrical mechanical devices that transform electrical current from alternating to direct current. A device called a transformer also is utilized to reduce the voltage or strength of the electric current down to the point desired for firing purposes. **Motor generators are located in the dynamo-room** of the ship, from which point the firing or motor-generator current is sent to each gun through suitable wiring.

The firing circuit is utilized also to light the sights and sight-setting mechanism at night.

The current furnished is small. **It is the present practice to deliver current under 10 volts' pressure at the guns both for firing and sight-lighting.**

FIRING KEYS OF GUNS: On some secondary battery guns where the elevating mechanism is actuated by a one-wheel drive, that is, the elevating wheel is single and operates by one ordinary handle, the **firing key is in the shape of a pistol grip.** The operation is simple; pressure on the trigger establishes the electrical connection by bringing a spring in contact with a contact nut. The two electric wires project out from the muzzle or forward part of the grip. This system contemplates having the pointer keep one hand on the elevating wheel to point and the other on the pistol grip during firing.

With the present type of elevating wheel, consisting of two parts revolving in opposite directions, each equipped with a handle on a spindle, the handles also revolving, and the

whole wheel operating in the hands of the pointer after the fashion of a bicycle, the handles operating as pedals, **the firing connection is made by the pressing of a simple push button, which is located in one of the handles of the elevating wheel, under the thumb of the pointer.** The electric wires enter the bottom of the handle containing the push button.

While the general idea is to use the percussion method of firing simply as an auxiliary in case of failure of the electric system, many ships are now combining both systems, so that there will be no cessation of firing for even a short time in the event of the failure of electric firing; that is, every time a gun is fired, both the percussion and electric systems operate.

ELECTRIC SIGHT-LIGHTING EQUIPMENT

Electric current is supplied from the firing circuit, whether the current is taken from storage battery or motor generator, for lighting the sights of guns during night engagements. **One candle-power electric lamps are located at the telescopes of pointer and trainer, at the sight-setting apparatus, and at the peep-sights.** These lights are operated from the switch-box on the gun mount.

ELECTRIC FIRING CIRCUIT

SWITCH-BOX: In order that the same circuits may be used whether the current is taken from the motor generator or from the storage battery, a **switch-box is used to transfer the source of current from one to the other.** The switch-box has a number of sockets, usually eight, and each socket has two terminals, one for the supply of current to lights and firing circuit and the other for the return of the current. The switch-box is located, as a rule, on the side of the gun mount. **By turning the handle you can connect up with motor generator or batteries, for both firing and sight-lighting or for firing alone.**

FIRING CIRCUIT: One terminal of the socket of the switch-box which carries the single conductor cable which

leads to the firing key is grounded to the gun mount. By this is meant that the supply wire from this socket goes direct to the firing key and causes the gun to fire. The other or return wire is grounded or connected to the lower part of the gun mount. **When the firing key is pressed, current passes from battery or motor generator to the switch-box, through it to the firing key, thence to the firing terminal on the breech of the gun, through center of firing lock and firing-pin, wire bridge and primer case, thus firing gun.** From the primer case the current goes on through the gun mount, and is attracted to the terminal of the return wire which was grounded on the mount. It passes through the return wire back through switch-box to its source of supply, thus following a complete circuit.

On the breech of the gun are found two terminals, one on the plug and one on the breech face of the gun. The terminal on the plug is connected by an electric wire to the insulated firing-pin in the firing lock. The terminal on the breech face of the gun connects by wire to the firing key. When the plug is rotated fully closed, or just before it is fully rotated, the terminal ends connect, **establishing the electrical connection as soon as the firing key is pressed.** This also forms a safety device, preventing the gun from firing until the plug is rotated fully closed.

CARE OF ELECTRIC FIRING ATTACHMENTS

The batteries should be frequently tested with a "voltmeter", which measures the strength of the current. The various parts of the circuit are tested with a "battery tester" and the circuit as a whole with an "ammeter" to measure the amperes or amount of current; or the entire system is tested by firing a primer. **Unless the electric firing connections are perfect and securely held in place, there will be frequent failures to fire, due to insufficient current passing through the primer.**

The best test of electric firing connections and battery strength is the frequent testing of primers by firing.

The most common causes of trouble are:

Broken wires.

Grease, dirt, or foreign matter on the connections or primer case.

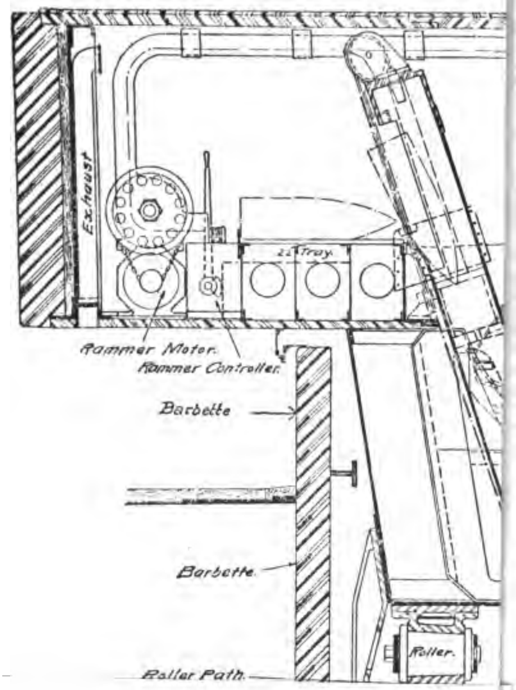
Poor or broken connections; not carefully tested before firing or jarred out during firing.

Insufficient voltage. (Battery run down.)

Defective primer. (Rare.)

Ground on the circuit. Current not passing through its circuit but being deflected and dispersing through gun mount or ship's structure.

Failure of pointer to close contact by not properly pressing firing key. (Most frequent.)


Exhaust
Tray
Rammer Motor.
Rammer Controller.
Barbette
Barbette
Roller.
Roller Path.

Chapter IX

TURRETS

PRINCIPAL PARTS AND MECHANISMS — DETAILED DESCRIPTION, TWO-GUN, 12-INCH AND 14-INCH TURRETS — TURRET AMMUNITION SUPPLY — THREE-GUN TURRETS

Modern turrets comprise a number of various types, from the super-imposed turrets used on ships of the U. S. S. *Virginia* and U. S. S. *Georgia* class, to the three-gun, 14-inch turrets used in the latest super-dreadnoughts such as the U. S. S. *Pennsylvania* and U. S. S. *Arizona*.

Inasmuch as the development of turrets is still in a transitory stage and as there are such a number of various types still in use, an effort will be made only to describe generally the type of turret most commonly found in use at the present time, and such turret mechanisms as have at this date proved most satisfactory.

Following along these lines we will give our attention particularly to the **two-gun, 12-inch turret mount found on all except the very latest of our new super-dreadnoughts**; these ships mounting three guns in each turret.

The turret itself is heavily armored, the armor being from twelve to sixteen inches in thickness. This armor plate extends all around the sides of the turret. The top of the turret is also armored, but the plate is not nearly so thick as on the turret sides. The tops of turrets are usually quite flat or slightly convex. The front, or portion through which the gun muzzles project, is inclined about 45° upward from the horizontal and is slightly convex toward the sides, the aim being to deflect any projectiles striking the armor. The

other sides are circular, or oval, with the longer axis of the turret in the direction of the fore-and-aft line of the vessel. On a modern turret every surface is curved; there are no plane flat surfaces. There is a departure from this in the turrets on the U. S. S. *Mississippi*, our newest super-dreadnought, the sides making obtuse angles.

The latest practice in our Service is to mount all turrets on the center line of the ship; in this way all guns can be used in either broadside, as desired.

In pre-dreadnoughts where we have only two 12-inch turrets, one forward and one aft, they are both on the center line of the ship, and are numbered 1 and 2 from forward aft.

On dreadnoughts where we have several turrets of the same caliber on the ship's center line, they are numbered consecutively, 1, 2, 3, — from forward aft.

On ships of the U. S. S. *Connecticut* class, where there are four 8-inch turrets on broadside, these are numbered from forward toward aft on each side, odd numbers to starboard. Thus, the forward turret on the starboard side is No. 1 and on the port side No. 2, etc.

In a two-gun turret, the guns are designated the "right" and "left" gun. In a three-gun turret, they are designated, right, left, and middle guns.

Inside the turret, a narrow passageway divides the guns, the passageway running fore and aft in the turret and dividing it exactly. Each gun, therefore, is in its own separate compartment and the crews are entirely separate.

The passageway is fitted with voice tubes, telephones, etc., from and to fire control station. **It terminates, in the front of the turret, in a small booth, which is the station of the turret officer**; also the turret trainer. The actuating mechanism of the electrical controller for the turret training is located in this booth, as well as the trainer's sighting telescope.

The TURNTABLE is the part on which the whole turret is mounted. The turret armor and all revolving parts of the mount are secured to it. It is built up of heavy steel plates **and beams, or angle-irons, and it rotates on line rollers which**

travel on a roller path built up inside the barbette framing. **The turntable is that part of a turret mount that causes the whole turret and the turret guns to move in a horizontal plane, or in train.** It corresponds to the **carriage in a broadside gun mount.**

The **BARBETTE** of a turret is a circular plate or belt of **exceptionally heavy armor, protecting the vital parts of the turret mechanism.** It extends from the armored or protective deck upward (protecting, usually, the upper part of the handling rooms, the turret training mechanism, the gun mounts, etc.). **It extends past the turntable, and projects upward through the main deck for several feet** until it comes up against the bottom of the turret itself, leaving about one inch of clearance, so as not to interfere with training the turret. The barbette is in the form of a true circle inclosing all parts of the turret mechanism and handling rooms, between the bottom of the turret and the protective deck. The portion of the handling room below the protective deck is protected by this deck. **The barbette is fixed in position.** The turntable is supported inside the barbette, on its rollers, and the **revolution of the turntable causes the turret, above the barbette, to revolve or move in train.** The **turret armor** protects the guns and the upper part of their mountings.

All the machinery of a modern turret is electrically operated and controlled.

The **TRAINING MECHANISM** consists of two constant-speed electric motors of from 25 to 50 horsepower each. These motors drive **universal-speed oil-motors** which, through a system of worms and worm-wheels, operate vertical shafts, at the end of which are geared or toothed pinion wheels. **These pinions engage in a geared circular rack, which is usually fastened to the inside of the steel-work framing, the top of which forms the turret roller path** and which extends up inside the barbette. The motors and pinions are mounted underneath the bottom of the turntable. **Thus, the revolution of the pinions, mounted under the turntable and engaging in the teeth of a stationary rack, mounted on the**

stationary framing, inside the barbette, causes the whole turret to revolve or move in train. The **worm-wheels** between the motors and the vertical training shafts carrying the geared pinions are attached to the vertical shafts by **heavy friction disks,** similar to those used on the mechanism of broadside mounts. These **friction disks** yield to the twist given the turret on firing one of the guns, and prevent the training gear from being deranged.

One motor can carry the load incident to training the turret so that if one motor breaks down no interruption to training occurs.

The **ROLLER–PATH** is built up on a heavy circular steel framing or structure extending upward inside the barbette, **and it is on this path that the lower part of the rollers, imposed between the turntable of the turret and the part of the ship or framework supporting the weight of the turret proper, rests.**

The **ROLLERS** are in the shape of truncated or cut-off cones, resting on their sides on the roller-path. Axles run through the rollers in the direction of their length. Supporting these axles, one at each end, and at the tops and bottoms of the circular line of cones (which are lying on their sides), and spacing them, are **two floating rings, or comparatively thin metal flanges.** The weight of the revolving part of the turret installation rests and turns on the rollers, and the horizontal thrust of the guns in recoiling is transmitted to the ship by the **roller flanges** and by the conical shape of the rollers.

DECK LUGS are heavy supports (two for each gun), the bottoms of which are securely bolted to the turntable, and the tops of which form the **trunnion-seats,** which support the trunnions of the **gun-slide** and the **gun itself.** They correspond to a part of the carriage of a broadside gun.

The **GUN–SLIDE** is almost exactly similar to the slide on a broadside mount. It is in the form of a sleeve encircling the gun and composed of several castings bolted together. It is bushed or lined with bronze to make easier the motion of the gun in the slide during recoil and counter-recoil. The

principal slide casting is at the trunnions or balance point of the gun and slide combined, and is approximately five feet long. There is a shorter slide casting encircling the gun near the breech, and giving it additional support. This shorter slide casting is securely bolted to the larger one, and is stationary with it during recoil and counter-recoil of the gun. **The TRUNNIONS are parts of the slide** and project one from each side of the slide. They are located at the center of gravity, or balance point, of the slide and gun combined. **The trunnions bear or support the slide and gun in the trunnion-seats of the deck lugs. It is on the trunnions that the guns are elevated. Frictionless trunnion-bearings,** similar to those on broadside mounts, are used. These, by means of small rollers imposed in the trunnion-seats, render elevation of the guns comparatively easy.

The ELEVATING–GEAR of each gun is operated independently, being actuated by a 15 horsepower motor. The elevating-motors operate "**Waterbury variable-speed gears**", connecting in turn to a **bevel-gear or wheel**. This bevel-gear is held by a feather joint to the **elevator-shaft** in such a manner that the **shaft may have a slight downward motion through, but must revolve with, the bevel-wheel.** The entire mechanism is carried on a heavy bracket which is bolted to the top of the turntable floor. By turning the elevating-motor in either direction, the elevator-shaft is revolved, and, it being practically restrained from a motion of translation (in the direction of its axis), a **traveling-nut** which is operated by the elevating-shaft is moved along its guides. This **traveling-nut,** having the lower ends of the **connecting-rods of the gun** secured to it, causes the breech end of the gun to elevate and depress.

In later ships the elevating-gear follows exactly the same principle as above, except that the elevator-shaft is made in the form of a large turn-buckle. One standing part is hinged to the bottom of the gun mount near the breech; the other standing part is bolted securely to the bottom of the turntable or the deck of the turret. The threaded shaft, operating in both standing parts, connects on its lower end

with the bevel-gear from the universal speed-gear. In the same manner as described above, the revolution of the bevel-gear revolves the threaded shaft; this revolution spreads out the standing parts of the turn-buckle, elevating the breech end of the gun. Reversing the motor revolves the threaded shaft in the opposite direction and causes the standing parts to approach each other, so that the breech end of the gun is lowered. When the gun is fired, the preponderance of weight at the breech, due to the gun coming back in recoil, puts an extra severe strain on the elevating-gear. This is taken up by a slight "give" of the whole elevating-shaft, brought about by the manner of connecting the lower end of the shaft to the bevel-gear by means of a feather joint.

The movement of the turret guns in a horizontal plane is regulated by the training of the turret; that is, both guns train together when the turret trains. **Turret guns have no individual motion in train inside the turret.**

The elevation of turret guns is done independently for each gun by a separate elevating mechanism for each in the turret.

Turret guns must bear always in the same direction, the guns being parallel in vertical planes. **The elevation of two guns in the same turret may be different.**

RECOIL–CYLINDERS operate somewhat similarly to recoil-cylinders on broadside guns.

The latest type of 12-inch turret gun is equipped with only one recoil-cylinder instead of two. This cylinder is a part of the gun-slide, being bolted securely to the slide. The piston rod is secured to a yoke encircling the gun near the breech and having a large lug or apron projecting down from its under side. The cylinder and piston rod are located underneath the rear part of the gun.

The recoil-cylinder differs from those of broadside mounts in that the counter-recoil springs are not in it, but are in separate smaller "counter-recoil cylinders", located two on each side of the recoil-cylinder.

The recoil-cylinder, instead of having grooves in its inside wall, permitting the liquid to pass around the piston head as in broadside mounts, is **fitted with two "throttling rods"**

which extend from end to end inside the cylinder, being fixed in position. These throttling rods taper; their largest cross-sectional area is at each extreme end (at after and forward ends of the cylinder). The smallest diameter is at the center of the rod and cylinder. **Two holes are bored in the piston head which pass over the throttling-rods during recoil of the gun.** When the piston head is at the forward end of the cylinder, the holes in the piston head are only slightly larger than the diameter of the rods. The diameter of the rods, however, decreases toward the center of the cylinder in a gradual curve, increasing the area between the rods and the holes in the piston head. At the center of the cylinders the rods attain their point of smallest diameter, and from the center to the other end of the cylinder, the diameter of the rods increases in a gradual curve, until at the end of recoil the rods again practically fill the holes in the piston head.

The cylinder is filled with 80% glycerine and 20% water as in broadside mounts. From the beginning of recoil, when the piston is at the forward or muzzle end of the cylinder, the flow of liquid between the rods and the holes in the piston increases in proportion to the amount of area presented to the flow. The speed of recoil of the gun in its slide increases rapidly until the maximum amount of flow is reached (the center or middle point of recoil). During the last part of the recoil, conditions are reversed, the flow of the liquid diminishing in proportion to the diminished area presented to the flow. This retardation of flow causes the speed of recoil to decrease rapidly. This method of checking the recoil, in conjunction with the counter-recoil springs, reduces to a minimum the shock incident to the recoil of a heavy gun.

During counter-recoil, the recoil-cylinder operates in the same manner as in recoil, only in reverse direction.

Four counter-recoil-cylinders are provided to bring the gun back "in battery", after recoil. These are located two on each side of the recoil-cylinder, one over the other, but in practically the same level with it. **Each cylinder is fitted inside with nine sets of double springs, but has no liquid in the cylin-**

der. The piston rod in each cylinder is connected with the yoke on the gun and comes back with the gun in recoil. The springs are located between the piston head and the after end of each cylinder. They are in a state of **initial compression**, which holds the gun in position " in battery", and prevents any motion of the gun in its slide due to rolling or lurching of the ship.

During recoil, the piston rods and pistons come back with the gun. This " highly compresses " the springs, which, when maximum recoil has been reached, reassert their tendency to expand and force the gun back " in battery."

The average length of recoil of a 12-inch gun and the average length of piston travel is 33 inches.

On a number of larger ships of the pre-dreadnought type, such as the U. S. S. *Connecticut,* the 12-inch turret guns are fitted with two recoil-cylinders, containing liquid, but no springs. The counter-recoil springs are located underneath the gun and are not inclosed.

AMMUNITION HOISTS in modern ships are usually of what is known as the **closed-tube, bucket type.**

The **projectile** is brought up to the turret proper through single-tube hoists, one for each gun. The **powder** is passed up from the lower handling room by hand.

The turret is entirely closed off from the handling rooms. The hoist, of course, passes from the handling rooms to the turret, but the hoist tube is closed by the bucket, which carries the projectile. The projectile is carried up through the hoist base end up. **A separate hoist for projectiles is provided for each gun** in a two-gun turret, and each hoist is separately controlled by an electric controller in the turret proper. Each hoist and controller is operated by a " hoistman", on signal to and from the handling room by means of an indicator. Voice-tube connections are also provided.

The powder is passed from the lower handling room by hand, a series of stages or platforms and ladders being provided. These reach from the floor of the lower handling room to the powder box of the turret (located in center of turntable). On each platform a man is stationed. The

powder bags are taken from the tanks in the handling room, then passed by hand from man to man, until the last man passes them through the powder box into the turret. **The powder box is provided with flap doors which are kept closed except when powder is actually being passed through them.** A charge of powder for one firing (4 bags) is all that is sent into the turret at a time. Then the powder-box doors are closed until the charge has been fired, when they are opened on signal to pass up another charge.

The most common type of hoist in use at the present time is the **two-stage hoist.** Where this is used projectiles and powder are stowed in magazines and shellrooms leading off the lower handling room. **The powder is passed up by hand.** The shell travels upward in its first stage, vertically and point uppermost in a vertical tube, from the lower to the upper handling room. Here, it is shifted automatically on to a tray and then carried base end up through its second stage from the upper handling room to the turret proper, in a tube hoist, slightly inclined from the vertical, in order to bring the shell up on to a loading tray in rear of the breech of the gun, in the turret. **The upper handling room revolves with the turret**, the whole room being constructed of sheet steel and suspended, bucket or basket fashion, from the turntable, inside the framing which supports the turret. **The break in the hoist occurs at the bottom of the upper handling room, the revolution of which (the lower handling room being fixed) makes the two-stage hoist a necessity in some ships.**

In the very latest type of ship, a single-stage hoist is used, leading only from the upper handling room to the turret. The projectiles, instead of being stored in shellrooms, are stored point down in racks around the sides of the upper handling room. The powder is passed by hand.

In a few ships single-stage hoists, carrying powder and projectile both, will be found; notably in super-imposed turret ships of the class of the U. S. S. *Nebraska* and *Virginia.*

ELECTRIC RAMMERS are provided in all turrets for the purpose of seating the heavy projectile in the gun. These are mounted in the rear of the loading tray, at the breech

of the gun, on which the projectile lies on its side before being entered in the gun bore. It is operated by a small motor equipped with a hand controller, and in seating the shell the rammer expands outward and forward after the fashion of a telescope. **It is called a telescope rammer.**

In a few dreadnought turrets, a rammer is used which moves in elevation with the gun, being attached to the under part of the gun by means of heavy brackets. This obviates the necessity of bringing the gun back to normal, parallel position for every loading, as is necessary when fixed rammers, located in line with the axis of the gun bore, are used. In the latest super-dreadnoughts, however, there has been a return to the use of the fixed rammers and single loading position.

In many cases, wooden hand rammers are used, and it is claimed that better results are often obtained with the **hand ramming** home of shells.

The **UNIVERSAL SPEED–GEAR** used in training the turret, and in elevating turret guns, makes possible motion at a slow or at a comparatively fast rate. **It provides variable speed of train and elevation.** The mechanism is simple.

TURRETS ARE SECURED FOR SEA in their normal position (gun muzzles forward or aft) by means of:

1. **Locking-bolt.** This passes through the turntable to a socket near the top of the barbette. It will go in place only when the turret is accurately placed in a securing position.

2. **Turn-buckles.** Outside of turret at every few feet. Secure turret to barbette armor.

3. **Wedges.** Four. They are set up between turret and barbette armor to prevent any strain on rollers as ship lists.

In addition to all the foregoing equipment, **turrets are fitted with blowers, for forced draft and ventilation during firing,** and a **system of bells and buzzers and fire-control instruments.** Each gun is fitted with a **gas-ejector.**

Modern turrets are each fitted with **individual range-finders inside the turret.** The arms of the range-finder project sideways from the front of the turret one on each side.

THREE-GUN TURRETS

In the newest three-gun turret ships the mechanism will be found considerably different from that described in the foregoing.

In three-gun turrets, there is no steel partition between guns as in two-gun turrets. The three guns are mounted in one combination sleeve or slide in an open turret, and are fired together. The guns all move in train and in elevation together.

It is claimed for these turrets that the mechanism is less complicated and that a smaller crew is made possible, while an additional weight of broadside charge is brought about.

The ammunition supply is less complicated. Projectiles are stored in an upper handling room or in a " ready ammunition room " right under the turret itself. They are sent up in two hoists, one between the right and center guns, and the other between the center and left guns — the first projectile is always loaded into the middle gun, no matter on which hoist it comes up; the outboard guns are then loaded each from its own hoist. The powder is passed by hand from magazines on each side, flap-doors opening from them, while charges are being passed through.

It is understood that in the new three-inch gun turrets, now under construction, steel bulkheads will separate the guns, each being in a separate compartment; also the guns will each be mounted in a separate slide and be elevated and fired individually, rather than together.

CHAPTER X

GUNPOWDER AND EXPLOSIVES

SMOKELESS POWDER — TYPES OF EXPLOSIVES AND THEIR PROPERTIES — GUN-COTTON; TNT; DUNNITE, ETC.

EXPLOSIVES, as a term, includes the several grades and classes of **gunpowder,** as well as all explosive compounds and mixtures used in the United States Naval Service.

All explosives are divided, first, into three distinct classes, according to the particular character of their action in exploding.

They are as follows:

1. **Progressive or propelling explosives.** This class (**called low explosives**) includes, principally, **smokeless powder,** and, generally, **all gunpowders,** and derives its name from the fact that almost its sole use is as a propelling explosive charge in a gun, or in firearms, and by its conversion into gas propels the projectile through and out of the gun bore; also its action is comparatively slow and progressive.

2. **Disruptive or detonating explosives.** This class (**called high explosives**) is very much quicker in its action, and is disruptive in exploding, breaking up or fragmenting its container. It includes all the various forms of high explosives used in the Navy, such as Gun-Cotton, Explosive "D" (Dunnite); Trinitrotoluol (TNT); Picric Acid; Nitroglycerine; Dynamite, etc. Explosives of this nature are used principally as bursting-charges in projectiles or torpedoes, and for demolitions of all kinds — blowing up bridges, buildings, etc.

3. **Exploders or detonators.** This class (**called fulminates**) is very much quicker in action than any other explosive — almost instantaneous (brusque). It consists principally of **fulminate of mercury** made up in the form of caps, and is used to originate explosive reactions in all other classes of explosives.

GUNPOWDER — PROGRESSIVE (PROPELLING) EXPLOSIVES

Practically the only form of gunpowder used to any extent at the present time is **smokeless powder. Black powder** is still used to a limited extent for special purposes, and **brown powder** was used to a limited extent until a few years ago, but is no longer issued to the Service.

BLACK POWDER is an intense coal black in color and comes in various sized grains. It looks like fine, black coal. Only small-grained black powder is now in use, except for saluting-gun charges, when a comparatively large, irregularly shaped grain is used.

Black powder is an intimate mixture of 75 parts of saltpeter (Potassium Nitrate, KNO_3), 15 parts of charcoal, and 10 parts of sulphur. It is quicker acting than smokeless powder, and for this reason **a small ignition charge of black powder is used to ignite more quickly a propelling charge of smokeless powder in a gun.** The only other present uses for it, aside from saluting charges and ignition charges, are as a bursting charge in a small-caliber projectile, as has been explained under "Projectiles", and as an ignition charge in some "fuses" and "primers." **Black powder is never now used as a propelling charge.**

BROWN POWDER was used extensively about twenty-five years ago, but is no longer issued to the Service. It is small-grained, the color of cocoa (dark brown). The peculiar color is caused by the charcoal in its composition being "underburnt." The composition of this powder is very similar to that of black powder, the amount of saltpeter being increased 2 or 3% and the amount of sulphur decreased in proportion.

SMOKELESS POWDER is the only powder now used as a propelling charge for a projectile in a gun, and its use is practically limited to this purpose. This, of course, includes all uses to which a **powder** can be put for naval purposes except as saluting, bursting, and ignition charges.

In appearance, Navy smokeless powder is in the form of grains, varying in size according to the caliber of the gun in which it is to be used. Each grain is in the form of a small cylinder. Grains to be used in charges for large-caliber guns are as large as $\frac{3}{4}$ inch in diameter and $1\frac{1}{2}$ inches in length. For a six-inch caliber gun the grains are about $\frac{1}{4}$ inch in diameter and 1 inch in length. **They are known as multi-perforated, being pierced in the direction of the axis of the cylinder with seven holes, each about $\frac{1}{32}$ inch in diameter.** The size of the grains decreases with the caliber of the gun, down to a minute grain used in the 30-caliber Springfield Rifle cartridge. This grain is also in the form of a cylinder, with one perforation in the direction of its axis. It is about $\frac{1}{16}$ to $\frac{1}{8}$ inch long and about $\frac{1}{32}$ of an inch in diameter. The size of smokeless powder grains is in direct proportion to the calibers of the guns in which they are employed.

In color, smokeless powder varies from a light lemon to a dark brown, almost a black, the variations in color depending largely upon slight variations in the process of manufacture. **The grain is hard and tough and is translucent.** Its general appearance can be likened to that of a "stick of lemon candy." Some grains are dyed red.

COMPOSITION of smokeless powder is accomplished by the dissolving of gun-cotton or nitro-cellulose in a mixture of ether and alcohol. Nitro-cellulose in certain degrees of nitration is perfectly soluble in ether and alcohol at ordinary temperatures, dissolving into a jelly-like substance, which, after the solvent is evaporated off, becomes a hard, tough, translucent mass, in which form it is smokeless powder.

Gun-cotton is made by subjecting a picked cotton fiber to the action of a solution of nitric and sulphuric acids.

This gives what is known as **nitro-cellulose, or gun-cotton, and is called the process of nitration.** There are several grades of gun-cotton, depending altogether on the degree of nitration, of which there are three.

In the third degree of nitration, where the percentage of nitrogen is over 12.75%, the **gun-cotton** is **insoluble** in ether and alcohol, and in this form it is used as an explosive of the detonating or disruptive type. **In the second degree of nitration,** where the percentage of nitrogen is between about 12 and 12.75%, the gun-cotton is soluble **and it is from gun-cotton in this form that smokeless powder is made.** In the first degree of nitration, the gun-cotton, while soluble in an ether and alcohol mixture, would give a smokeless powder of insufficient strength.

Smokeless powder under proper pressure may be pressed into any desired shape. It will not detonate or explode by such pressure. A grain of the powder may be held in the hand and lighted with a match. It will burn regularly and evenly without smoke.

ADVANTAGES of this powder are that no smoke is caused by its explosion; the entire charge is converted into gas which is utilized in expelling the projectile; it is more compact than other powders and therefore easier to handle and stow; gives greater muzzle velocity to the projectile and does not foul the bore of the gun.

Black powder, on the contrary, when used as a propelling charge, creates a quantity of dense, black smoke. It has been figured out that 65% of a black powder charge is dissipated in smoke and residue (which clogs the gun bore and rifling), while only 35% is converted into gas for the expulsion of the projectile.

MANUFACTURE OF SMOKELESS POWDER

The following very brief summary of the steps taken in the manufacture of smokeless powder is set forth merely to give a general idea of the process.

(1) **Picking** the cotton fiber or waste to remove lumps

and foreign matter, the cotton being run through specially fitted corrugated iron drums.

(2) **Drying** by means of hot air at a temperature of 105° C. for 8 hours to reduce the natural moisture to a maximum of $2\frac{1}{2}\%$.

(3) **Nitrating** by means of immersion of dry cotton in charges of 30 pounds each; in solution of nitric and sulphuric acids for 20 minutes or until cotton has absorbed from 12.5 to 12.75% of nitrogen. When dry, the weight of cotton, due to nitrogen assimilated, has increased to 41 pounds.

(4) **Drowning** — The nitrated cotton or **pyro**, as it is now called, is immersed in fresh water to remove free acids.

(5) **Boiling** — 1000-pound charges of pyro are boiled 40 hours at 100° C. and washed five times to remove free acids.

(6) **Pulping** — 1025-pound charges of pyro are ground in contact with water for from 8 to 12 hours to break up tubular cotton fibers. Water is then bailed off.

(7) **Poaching** — 3075-pound charges, or 3 pulping charges of dry pulped pyro, are boiled 12 hours at 100° C., the water being changed five times. It is washed for $\frac{1}{2}$ hour and drained for 1 hour, ten times.

(8) **Testing** — Sample of pyro from poacher is chemically tested by heat test in laboratory.

(9) **Wringing** — From poachers pyro is wrung as dry as possible in cotton-towel-lined wringers.

(10) **Dehydrating** — Charge of pyro is submitted to pressure of 200 pounds per square inch to force out all water. Alcohol is then forced through charge at 75 pounds' pressure, until water is all out. The charge is then caked by 3000 pounds' pressure, maintained from one to three minutes.

(11) **Mixing** — 100-pound charges of dehydrated pyro are ground by knives for 20 minutes, ether, alcohol, and diphenylamine added, and the charge again mixed for 30 minutes. **The whole charge is now a plastic mass of nitrocellulose dissolved in ether and alcohol.**

(12) **Pressing** — Under pressure of from 1000 to 2000 pounds, cakes are forced through $\frac{3}{32}$ inch holes in a strainer

press. From here to the blocking press, where cakes are again formed. The cakes are then forced through a die-press, from which the smokeless powder emerges in perforated cylinders or rods of the desired diameter. The rods are cut into grains of the desired length.

(13) **Solvent recovery** — Powder is submitted to hot air for 96 hours, at a temperature of from 30° to 39° C. By this process it loses 30% of its weight in volatiles. These volatiles are later recovered by condensation.

(14) **Drying** — The powder is now dried at air temperature for from two to two and a half months. It is later dried at 40° C. for from two to four months.

(15) **Airing** — Powder left 24 hours in blending house to absorb a normal amount of moisture from air.

(16) **Blending — 100,000 pounds of powder form one blending charge.** Powder is blended so that all the powder of an index is of an even mixture and so that any two powder bags of equal weight will contain the same quality of powder and give the same initial velocity under similar conditions. **A blending charge makes up or composes an index of powder.**

(17) **Boxing and Weighing** — Powder now is placed in air-tight boxes, weighed, marked, and stored for shipment.

ACTION OF GUNPOWDER

As has been stated before, **all gunpowder is included in the class of explosives called " progressive explosives "**, the term " progressive " referring to the action of the explosive in its conversion into gas.

In this action there are three separate and distinct steps, namely: **ignition, inflammation,** and **combustion.**

Ignition of ordinary gunpowder is accomplished by an electric spark, by contact with an ignited body, or by a sudden access of heat to 572° F. Gradual heat decomposes powder without ignition. Powder may also be ignited by friction or shock between two solid bodies.

Smokeless powder is more difficult to ignite than others. For this reason an ignition charge of black powder, pre-

viously referred to, is used. Smokeless powder, however, will ignite at a sudden access of temperature to 180° C., a much lower ignition temperature than that of black powder. These facts seem contradictory, but can be explained as follows: in the explosion of a propelling charge in a gun the flame from the primer, ignited by the fulminate of mercury cap, shoots forward; the flame, by direct contact with the ignition charge of black powder, ignites it, and the flame from the ignition envelops the smokeless powder and ignites its surface. If there had been no ignition charge, there would have been a possibility that the smokeless powder would not have ignited, as it is comparatively hard to set on fire by contact with flame. In the gun, however, smokeless powder ignites almost at once, at a temperature of 180° C. The rapidity of the ignition is due to the rapid expansion through and about the smokeless powder grains of highly heated gases, generated by the burning of other powder. **Ignition as a term, or process of an explosion, is the initial setting on fire of any part of a powder charge.**

Inflammation is the spreading of the ignition or flame from the point of ignition: first, over the surface of the powder charge, and then through the charge; that is, the flame which sets the first grain of powder to burning spreads to all other grains on the surface of a propelling charge and then extends through the charge, inflaming the interior grains. The period of time required to bring about inflammation of an entire charge is called the **velocity of inflammation.**

Combustion, the third action, is the consuming or conversion into gas of each individual grain of powder; combustion in each grain occurring from the surface inward.

The combination of the above three actions converts powder into gas, which, under the high heat generated in the gun chamber, expands, and forces the projectile from the gun.

The velocity of inflammation and also of combustion is increased or retarded by the size and shape of the individual grains of powder. This is the reason for the peculiar shape

of smokeless powder grains and the various sizes of these grains, depending on the caliber of gun in which used. **The shape of the grains permits the circulation of heated gases about them and the perforations admit heated gases through the grains. As combustion is almost entirely brought about by the heated gases generated, the grains undergo combustion rapidly from both exterior and interior.**

It is aimed to have the entire charge undergo combustion at practically the same time, so that the projectile will be expelled at high velocity, due to the expansive force of gases from the entire charge. If combustion were not uniform, gases sufficient in force to expel the projectile would be generated before complete combustion was effected and the projectile would leave the gun with a lesser velocity, while grains of smokeless powder, uncombusted, would be left in the gun bore.

The white cloud issuing from the bore of a gun after firing is not smoke, but gases from the propelling charge.

DETONATING OR DISRUPTIVE EXPLOSIVES

Explosives of the detonating or disruptive type include the following:

1. **Dunnite (Explosive " D ")**
2. **Gun-cotton**
3. **Trinitrotoluol (TNT)**
4. **Picric acid**
5. **Nitroglycerine**
6. **Dynamite**

The first three of these, **Explosive " D ", Gun-Cotton,** and **TNT, are the only ones used for naval purposes to any great extent. Picric acid** is probably the highest explosive of any and is used to a slight extent at the present time in our Service, principally and experimentally as a bursting charge in projectiles.

Explosives of this class are called high explosives. Their action is more of a detonation, and an ignition in part of a charge of this character is not slow and progressive as in

gunpowder, nor does it progress first over the surface of the charge. Rather, the ignition and explosive reactions are almost instantaneous, and progress radially in all directions throughout the mass of the charge. The effect is to transform the explosive in an almost inappreciably short time, from a solid to a gaseous state, the gases being greatly increased in volume and pressure by the heat of the combination.

Detonating explosives find their principal use as bursting charges in projectiles and torpedoes, and as charges in mines, counter-mines, etc.; also for demolitions such as blowing up bridges, buildings, etc.

The principal characteristics and uses of Explosive " D ", Gun-Cotton, and TNT will be briefly discussed.

EXPLOSIVE " D " OR DUNNITE derives its name from its inventor. Explosive " D ", as it is usually termed, is the designation common to the naval service. In appearance it is like a deep yellow, fine-grained, almost pulverized corn meal. This explosive combines most of the requisites necessary in a **bursting charge** for **projectiles,** and is used almost exclusively for this purpose in projectiles for guns over four-inch in caliber. It is a derivative of picric acid.

TRINITROTOLUOL OR TNT is a comparatively new explosive in the naval service. It has many valuable properties and is rapidly coming into extensive use. TNT comes in grain form; compressed; and molten or cast. In grain form the grains are small, although slightly larger than grains of Explosive " D ", as described in the previous paragraph. It also can be likened to corn meal, although the color varies from a light cream, almost a white, to a pale yellow. In the compressed form, the grains are compressed under high pressure into cakes. In the molten form the grains are heated and melted into liquid form. Hardening, this liquid is fused into solid cakes of dark brown color.

The value of TNT as an explosive is not in the high degree of its explosive reaction, which is not above other explosives, but in its chemical stability, its lack of sensitiveness to

shock, its safety during manipulation, and the absence of fire risks in connection with its use. It suffers no loss of explosive power through immersion in water.

TNT is detonated by electric or percussion primers. In its granulated form it is most easily detonated, and for this reason the granulated form is used as bursting charges in projectiles.

The **principal use of TNT** is as a bursting charge in projectiles; also it is now being used to supplant wet gun-cotton as a charge in mines, counter-mines, etc., and in torpedo war-heads, TNT in molten or cast form being used for this purpose, because of its unsusceptibility to water. Dry gun-cotton primers are being replaced by compressed TNT. For demolition work TNT is extensively used.

GUN-COTTON has been previously referred to under the caption of smokeless powder, to which it is closely allied.

The manufacture of gun-cotton to a certain stage is similar to that of smokeless powder. It is made from **cotton fiber.** This fiber is carefully picked to eliminate foreign material, after which it is washed, boiled, and dried, containing after drying a maximum of one half of one per cent of moisture. **The cotton is now nitrated, being dipped in a solution of nitric and sulphuric acids of the proportion by weight of one to three.** In the process of **nitration** the cotton must be nitrated to the highest possible degree, containing as a detonating explosive (Gun-Cotton), not less than 13.2% of nitrogen.

After nitration, the gun-cotton goes through various processes of washing (to remove free acids, etc.), pulping, and drying. It is then carefully tested chemically and otherwise.

Gun-cotton, for most purposes, is kept in the form of blocks, the size and shape of these depending on the particular use for which intended. For instance, a small rectangular block about 3″ × 4″ × 2″ is used for counter-mine and wrecking outfit charges. A larger rectangular block 8½″ × 8½″ × 2″ is used for automobile-torpedo charges and a small cylindrical block for dry primer charges.

These blocks are formed by feeding the gun-cotton through presses of particular types during which it is made compact by subjection to steady, heavy pressures.

WET AND DRY GUN-COTTON form two distinctive classes of this explosive.

Wet gun-cotton is simply **dry gun-cotton** to which has been added 25% by weight of pure distilled water.

Wet and dry gun-cotton as explosives are equally powerful, but dry gun-cotton is extremely sensitive and is more liable to decomposition. Wet gun-cotton, on the contrary, **is not sensitive and can only be detonated by the explosion of dry gun-cotton in immediate contact with it.** Dry gun-cotton can be exploded by a charge of fulminate of mercury.

Owing to the sensitiveness of dry gun-cotton and its tendency to decomposition, it is not carried in quantities aboard ship. It is only carried in primers for the wet charge. All gun-cotton blocks and gun-cotton in bulk carried on board ship consist of **wet gun-cotton,** and it is required that it be frequently inspected and kept wet to the percentage of 25% of water, for purposes of safety. If it should at any time become necessary to dry a quantity of wet gun-cotton, this can be best accomplished by exposing it in a steam drier at a temperature not above 100° F. or by exposure in dry atmosphere out of sun's rays.

Wet gun-cotton is used for packing torpedo war-heads, and for charging mines and counter-mines; also for wrecking charges. It is especially valuable for these purposes because of its imperviousness to water. It is being replaced to some extent by TNT in the cast form, which also possesses this property.

Dry gun-cotton finds practically its only present use as a primer for wet gun-cotton charges.

FULMINATES OR DETONATORS

An explosive of this type, as has been briefly explained, is probably the quickest in action of any. It is considerably

more brusque an explosive even than the disruptive, detonating type. The explosive reaction is almost instantaneous on impact at any part of the charge. **The form in which this class of explosive is known and used is as a "fulminate of mercury cap" in small-arm cartridges and in primers of every description, except electric.**

Chapter XI

PROJECTILES — FUSES

ARMOR-PIERCING AND OTHER TYPES — DESCRIPTION AND MANNER OF ACTION — FUSES FOR PROJECTILES — PRINCIPAL TYPES AND ACTION OF EACH; TRACERS

A **PROJECTILE** or shell is a missle fired from the muzzle of a gun; it is always the projectile, **whether issuing from the muzzle of a Breech-Loading Rifle, using separate ammunition, or from the muzzle of a Rapid-Fire Gun, using fixed, cartridge-case ammunition.**

Projectiles for guns of and above seven inches in caliber are called **major-caliber projectiles.** For guns of six-inch caliber and smaller they are called **minor-caliber projectiles.**

The various types of projectiles used in the United States Navy are listed as follows:

Armor-piercing
High capacity
Common (called common shell)
Shrapnel (common and high-explosive)
Blind or target

All projectiles now manufactured for use in our Service are made of **Open-Hearth steel,** such as is used for Gun parts and hoops, and which was described in connection with the manufacture of Naval guns. **There is, of course, no nickel in the Open-Hearth steel used for projectiles.**

In the **MANUFACTURE** of projectiles, the liquid molten metal from the Open-Hearth furnace is poured into **ingot molds** and made up into ingots of the approximate shape required. The ingots are then **annealed** and **later forged**

in a hydraulic forging press to the required shape. Another annealing now takes place to remove any stresses set up during the forging process, after which the projectiles are **machined** to the proper and final size. From the machine shop they are sent to the **treating-house** where they are specially hardened, **the point of the projectile being particularly tempered and hardened.**

Before finally accepted for use they are subjected to all manner of chemical and physical tests by government inspectors.

All projectiles are made of forged steel as above described except the Blind or Target shell used in Target practice. These are made of Cast Steel or Cast Iron.

GENERAL CHARACTERISTICS AND PRINCIPAL PARTS OF ALL PROJECTILES

Modern projectiles are all of the same general shape, **a long cylinder with an ogival shaped head.**

An **OGIVAL HEAD** is so termed from the peculiar nature of the radius required to describe the curve which brings the projectile to a point. The **ogival head** is that particular part of a projectile from the forward end of the section of even diameter to the point, or from the beginning of the forward slope to the point. The purpose of the **ogival head is**, that it offers less resistance to the air in the flight of the projectile than any other shaped head, and **at the same time masses a sufficient amount of metal at the point to give desired penetration when it strikes.**

The **BOURRELET** is a small section of even diameter at the base of the ogival head on a projectile. It is at the forward end of the section of even diameter or cylinder of the projectile, and is of slightly enlarged diameter over that of the rest of the projectile. **It serves the purpose of providing a bearing surface on the forward part of the projectile** and enables its more accurate seating in the gun bore; also it concentrates the spinning or revolution about the long axis of the projectile.

The **ROTATING BAND** has been referred to before. It is a soft copper band encircling the projectile at a distance of from one to two inches from the base. It is about one quarter of the caliber of the projectile in width; that is, for a shell of 12-inch caliber, the width of the rotating band would be three inches. **The diameter of the band is equal to that of the base of the grooves of the rifling in the gun tube or bore.** The function of the band is to give to the shell, as it travels down the gun bore, the rotation or rotary motion required and which is secured by the lands of rifling cutting into the soft copper band. Chips cut from the rotating band by the rifling fall into small grooves around the circumference of the band.

The forward edge of the rotating band is beveled, or slanted down, so that the projectile will start easily and there will not be too much strain on the rifling. When the projectile is seated in the gun, the bevel of the rotating band rests into and matches the bevel on the lands of the rifling. When the projectile is traveling down the gun bore, the joint between the lands of the rifling and the rotating band forms an effectual gas-check to prevent any gases from getting around in front of the projectile.

ARMOR-PIERCING PROJECTILE, known and abbreviated as an A. P. projectile, is one, as may be implied from the name, designed to pierce heavy armor plate, such as we find protecting the vital parts of modern dreadnoughts. The depth to which this projectile will penetrate armor is greater than that of any other manufactured, but depends, of course, on the caliber of the projectile and velocity with which fired from the gun. A projectile fired from a modern high-power 14-inch gun will penetrate armor plate over 16 inches thick at a distance of 9000 yards.

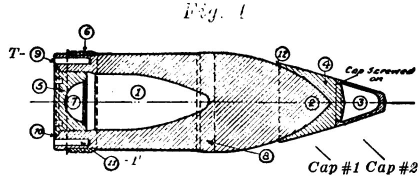
A typical armor-piercing projectile is shown in Fig. 1. The projectile proper is indicated and has the same general dimensions and the **ogival head** and point described for projectiles in general. **This point is extremely hard and well tempered.** Over the ogival head and point is a cap, indicated in the sketch as "**Cap #1.**" This is made of

comparatively soft steel and is rigidly secured to the projectile proper by an undercut score in the head, as shown in sketch.

It will be noted that the end of Cap #1 is very blunt, little metal being in front of the point of the projectile. There is a particular purpose in this which will be explained later. It should be carefully borne in mind.

The theory or reason of the soft steel cap on armor-piercing projectiles is, that when fired, the entire weight of the projectile is utilized; first, to bend in the armor plate to a degree near its breaking point. In this process the soft steel cap is crushed down around the sides of the ogival head of the projectile. Now, inasmuch as the point of the projectile is very hard and sharp, the whole projectile continues its motion forward, the hard sharp point cutting right through the soft steel cap, and striking, in a sense, another blow on the armor plate. The point of the projectile now pierces the already dented plate and the projectile itself enters through and explodes in the rear of the armor plate, or on the inside of the vessel attacked.

Fig. 1



ARMOR-PIERCING PROJECTILE, 12-INCH CROSS-SECTION VIEW

1, Cavity — seat of bursting charge; 2, Ogival point; 3, Thimble — wind shield — cap No. 2; 4, Blunt soft steel A. P. cap — cap No. 1; 5, Base plug — threaded in base; 6, Rotating or forcing band — — soft copper; 7, Seat of internal base fuse; 8, Bourrelet; 9, Seat of tracer; 10, Soft metal caulking around base plug; 11, Seat of tracer; 12, Undercut score — attaches cap to shell.

Now, returning to soft steel Cap #1, it is always the aim to have as little metal as possible in front of the point of the projectile so that the hard point will have no difficulty in piercing through when the projectile strikes, and so that no momentum is lost in so doing. The mass of the soft metal is found around the sides of the ogival head. On impact this soft metal is crushed down around the point and

head of the projectile and serves to support it as it pierces the armor plate. The only difficulty in the satisfactory use of this soft steel cap now presents itself. The very blunt end or large flat area at the head of the projectile offers too much resistance to the air in its flight and therefore materially reduces the effective range.

To overcome the aforementioned difficulty **there is screwed on to the blunt, forward end of Cap #1, another small, soft steel cap, this last cap being hollow.** It is illustrated in the sketch and is designated **Cap #2**. This cap is sometimes designated as a **wind-shield** for the reason that it brings the projectile practically to a point, and reduces to a negligible quantity the air resistance encountered by the blunt end of Cap #1. It is also known as a **thimble** from its shape and its hollowness. It is made hollow in order that no metal be massed in front of the point of the projectile, which is objectionable, as has been explained before.

Summing up on the use of the combined soft steel cap, **the long, tapering cap gives a range equal to or greater than that attained by the ogival-headed projectile; gives a better trajectory to the projectile; and gives a considerably higher striking velocity at equal ranges than an uncapped projectile.**

The **BURSTING CHARGE in any projectile is the powder or explosive which is located in a cavity or chamber in the center of it and the explosion of which fragments or breaks up the projectile.**

Bursting charges usually weigh from $2\frac{1}{2}\%$ to 3% of the total weight of the projectile. Thus in a 14-inch caliber, armor-piercing projectile, weighing 1400 pounds, the weight of the charge is $31\frac{1}{2}$ pounds. In a 12-inch caliber projectile weighing 870 pounds, the charge weighs 24 pounds. The charge itself consists of **fine grain black powder**; of what is commonly known in the Navy as **Explosive "D", being a very high explosive named "dunnite"**; or **of a new high explosive, recently coming into use, called "TNT."**

ARMOR-PIERCING projectiles have a **CAVITY** or **SEAT OF THE BURSTING CHARGE** opening from the

base and shown in Fig. 1. The bursting charge which fills this cavity in an A. P. projectile **has always been Explosive "D", but latterly "TNT" has been used.**

BASE PLUGS consist of threaded plugs of the same diameter as the seat of bursting charge. The powder or bursting charge is loaded into the projectile through the hole in its base; **the base plug is then screwed in and holds the charge in place.** All projectiles above six-inch caliber are fitted with base plugs. In Fig. 1 the base plug is indicated.

A **GAS-CHECK BAND** is in the base of the projectile and serves to make gas tight the joint where the base plug fits into the base of the projectile. It is formed by cutting a groove into the base of the projectile, half in the plug and half in the projectile itself. This groove is then filled with a copper and lead gasket, and caulked to make tight.

The reason for this **gas-check band** is that if the gases from the propelling charge in the rear of the projectile, in the gun when it is fired, should be forced into the projectile, **its bursting charge might be ignited and the projectile exploded inside the gun, prematurely, and with disastrous results.**

A FUSE is a mechanism fitted into a projectile and serving to ignite the bursting charge. For the present it will suffice to say that all fuses are first divided into two principal classes depending on their position in the projectile: **base fuses,** having their position in the base, and **nose fuses,** having their position in the head end or **nose** of a projectile. They are further classified by their manner of action into **detonating, ignition, and time fuses.**

Fuses will be gone into in detail later on in this discussion, but the above conveys the information necessary to understand the relation of fuses in general to projectiles.

ARMOR-PIERCING PROJECTILES are always equipped with **BASE FUSES,** the fuse being in position on the **inside of the base plug, in the hemispherical cavity in the plug shown in Fig. 1.** This type of fuse is particularly designated an **INTERNAL FUSE** and is used in all recently manufactured projectiles.

The term **internal** distinguishes this fuse from those of the **exterior type**, which are still in use largely in minor-caliber projectiles and which are screwed into the bottom and center of the base plug after the projectile has been assembled.

All fuses used in armor-piercing projectiles, in addition to the foregoing characteristics, are what are known as **DETONATING DELAYED-ACTION FUSES.** This is a particular type of fuse used in the United States Naval Service, the details of which are secret and cannot be published. **These fuses, however, contain a delayed-action element which permits a projectile to strike and pierce armor plate before detonating**; **thus the projectile fragments or breaks up on the inside of the armor.** The fuse cannot operate until the projectile has been fired from a gun, the projectile therefore being perfectly safe to handle. The **general theory of a delayed-action fuse** is that it utilizes a powder train of definite length. It is known that it will take a certain length of time for a projectile of particular caliber to pierce armor plate of known thickness. **The fuse ignites the powder train on impact of the projectile.** The powder train burns during the time the projectile is piercing the armor plate. **Simultaneously as the projectile passes through the armor, the powder train reaches the bursting charge in the projectile and causes it to detonate, fragmenting the projectile on the inside of the armor belt and the vessel.**

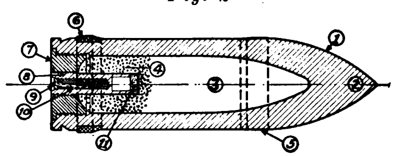
TRACER FUSES are base fuses fitted with a special tracer attachment. This type of fuse was invented by a man named Semple and is known as a **SEMPLE TRACER FUSE.** In the case of a minor-caliber projectile, the tracer element is contained in the same casting as the fuse itself and is a part of it. The fuse, which is of the **exterior type**, is then screwed in the center of the base plug of the projectile. When the projectile is fired, the tracer compound, which is a highly compressed, slow burning powder, is ignited by means of a friction element, and burns slowly, **leaving a trail of light from the base of the projectile in its trajectory**

and enabling spotters in night firing to accurately judge the flight and landing places of projectiles.

In the case of major-caliber armor-piercing projectiles, where the fuse is of the internal type, the tracer is entirely separate from it. These projectiles are fitted with **two simple tracers,** placed into cylindrical unthreaded holes in the base, 180° apart and just outside the base plug. The holes are made large enough for the tracers to be slipped in by hand. The metal of the projectile is upset slightly over the ends of the tracers so that they will not fall out during the flight of the projectile. These tracers operate the same as those forming parts of fuses. Holes for tracers are seen in Fig. 1, marked "T."

COMMON SHELL has the same external appearance as an armor-piercing projectile without a soft steel cap. It is made of forged steel; it is made with a base plug; and it has practically the same sized cavity as seat of the bursting charge as an armor-piercing projectile, but **differs from it in that in final form it has the regular ogival head and point, without a soft steel cap and that it is made in smaller calibers.**

Fig. 2



COMMON PROJECTILE — MINOR-CALIBER — CROSS-SECTION VIEW

1, Ogival head — in one piece with projectile; 2, Ogival point; 3, Cavity — seat of bursting charge; 4, Black powder — bursting charge; 5, Bourrelet — slightly enlarged diameter; 6, Rotating band — composition metal — soft; 7, Base plug; 8, External base fuse — tracer fuse; 9, Tracer ignition feature; 10, Tracer and tracer compound; 11, Fuse powder charge.

The bursting charge of a common shell is usually fine-grained black powder, but can be "Explosive D." When the charge is black powder, a **simple ignition fuse** is used; that is, one that explodes the bursting charge on impact of the projectile against its objective. This fuse is of the **external base type** and is used fitted with the tracer element. **When the charge is "Explosive**

D ", a detonating delayed-action fuse is used as with armor-piercing projectiles.

Common shell for guns above five-inch caliber are no longer manufactured.

HIGH-CAPACITY SHELLS have the same external appearance as an armor-piercing projectile without a soft steel cap. These shells are made for large-caliber guns only, and are designed, not to pierce heavy armor plate, but to destroy the upper works of battleships and pierce comparatively thin armor. With this end in view the walls of the shell are made thinner than those of armor-piercing projectiles and the seat of the bursting charge very much larger. The bursting charge consists of "Explosive D" and weighs up to 10% of the entire weight of the projectile, as compared with a relative weight of from 2½% to 3% of bursting charge in an armor-piercing projectile.

High-capacity shells are otherwise fitted with base plugs, fuses, tracers, etc., of the same types as armor-piercing projectiles of corresponding calibers.

SHRAPNEL in its use is confined practically altogether at the present time to guns of three- and four-inch calibers. It is no longer manufactured in calibers over four inch. Its principal use is against personnel, and for naval purposes finds practically its only use in connection with landing parties ashore or possibly against exposed bodies of men on deck.

A **shrapnel shell** is essentially of the same external proportions as other projectiles of the same caliber. It has an ogival head, but instead of this head coming to a point, there is a small hemispherical nose screwed into the head. This nose is made of bronze and is a **nose fuse,** such as is used only in shrapnel.

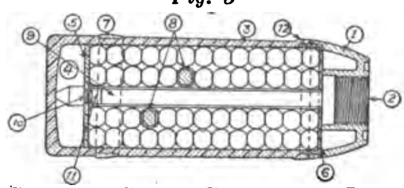
Shrapnel has no base plug, the base of the shell being a part of the casting. The **bursting charge is small and is located in the rear of the shell.** The walls of a shrapnel shell are thin and the **large interior or cavity is filled with a number of small spherical shot or steel-jacketed balls.**

These balls average about one half inch in diameter and are packed in rosin or in sulphur.

Shrapnel is divided in two principal classes, called **COMMON SHRAPNEL** and **HIGH-EXPLOSIVE SHRAPNEL.** The main difference between them is the character of the packing in which the small balls are loaded; in common shrapnel the balls being packed in rosin or sulphur for the purpose of producing smoke, etc., and in high-explosive shrapnel in some high explosive, such as picric acid or TNT. In the H. E. Shrapnel there is also a charge of some high explosive and a smoke producing mixture in the head of the shell.

A common shrapnel of 3-inch caliber is shown in Fig. 3. The **PRINCIPLE OF ACTION,** which covers all classes of shrapnel, will now be explained. It will be seen that in the interior of the shell there are two steel diaphragms, one just forward of the bursting or propelling charge and the other at the point where the slope of the head from the cylinder begins. Between these two diaphragms all the balls are located. In the base of the shell, to the rear of the diaphragm, is located the bursting charge of compressed powder. The nose, which is a **combination time and percussion fuse,** is screwed into the head, and communicates with the bursting charge by means of **a powder-lined tube down the center of the shell.**

Fig. 3



SHRAPNEL SHELL (COMMON) — 3-INCH — CROSS-SECTION VIEW

1, Shrapnel head — screwed on — malleable iron; 2, Threads to receive "Nose Time Fuse"; 3, Body or case of shell — one piece — drawn steel; 4, Bursting charge — compressed powder; 5, Rear diaphragm — sheet steel; 6, Forward diaphragm — separate steel disk — joins head and body — threaded to each; 7, Rotating or forcing band — soft copper; 8, Steel jacketed balls (234); 9, Powder-lined paper tube; 10, Silk gauze between charge and powder-lined tube; 11, Diaphragm plug and nut; 12, Bourrelet.

A shrapnel to be properly effective should explode about fifty yards in front of its target while still in the air. This is accomplished

by means of a time element on the nose fuse. Before the shell is placed in the gun, the fuse is set so that the shell will explode a certain number of seconds after it leaves the gun. If the target should be reached before the explosion takes place, due to an error in the time setting, the shrapnel will explode anyway by means of the percussion element in the fuse. When the charge in the fuse is ignited, either by percussion or time, the spark is conveyed through the powder-lined tube to the bursting or driving charge in the base of the shell. **The explosion of this charge forces both diaphragms forward**; the head of the shell, being comparatively insecurely attached, flies off due to pressure from the forward diaphragm and should fragment. The small balls due to sudden pressure from the base diaphragm and the action of the explosive about them, plunge forward in a shower. The body of the shell itself should be fragmented by the explosion of the bursting charge. The principal damage is caused by the effect of the small balls or shot on personnel.

BLIND OR TARGET projectiles are made of cast steel or cast iron. They have the external appearance of a **capped armor-piercing projectile.**

The only use of these projectiles is in target practice. The cavity is filled usually with sand, but can be filled with any substance which will give the shell the desired weight. **These projectiles are never fitted with fuses and have no bursting charge, but do have tracers when used in night practice.** They are essentially "blind" or "dummy" shells; their only requisites being shape and weight.

MARKING AND PAINTING PROJECTILES

Major-caliber projectiles are marked on the base with the name of the manufacturer; the weight, the lot number and date of specification. **On the rotating band** with the mark and modification number, caliber, kind, such as A. P., and initials of inspector.

Minor-caliber projectiles have practically the same information on the base but only the inspector's initials on the band.

PAINTING the exteriors of projectiles is invariably used as a means of determining at a glance the type of projectile and character of the charge.

The entire surface of a projectile is painted, with the exception of the base, fuse, rotating-band, bourrelet and nose (for a distance of one caliber from the point). The color indicates the type of shell as follows:

Armor-piercing . . .	**Black**
Common	**Lead color**
Shrapnel	**White with Red head to rear of nose fuse**
Blind	**Red**

The only exception to the above is the blind or target shell on which the entire ogival head is painted red and the rest of the shell greased or vaselined.

Projectiles for fixed ammunition are not painted in the rear of the rotating band but are given a heavy coat of grease.

Painting the nose of a projectile for a distance of one caliber from the point indicates the character of the **bursting charge.** The colorings are as follows:

Black Powder . . .	**Lead color**
Explosive "D" . . .	**Yellow**
TNT	**Green**
Blind Shell (no charge)	**Red**

Painting a white band, one inch wide, around the nose just above the color indicating the bursting charge means that the projectile is equipped with a **tracer or tracer fuse.**

PROJECTILES FOR VARIOUS CLASSES OF GUNS

Armor-piercing and **high-capacity projectiles** are the only ones now manufactured for **major-caliber guns**; guns from seven- to sixteen-inch calibers; some large-caliber **common**

shell are still in use but these are no longer manufactured for guns of over five-inch caliber.

For guns of three, four, five, and six-inch calibers, fifty calibers long, armor-piercing and common projectiles are in use; also shrapnel, but these are no longer manufactured for guns of over four-inch caliber.

For three-inch field pieces, high-explosive and common shrapnel are practically the only projectiles used.

Six, three, and one-pounders use only solid steel shells.

CARE OF PROJECTILES

All projectiles such as have been described belong to the service outfit of the ship; that is, they are a part of the equipment to be used only in active battle. For this reason they must be given the best of care. **The following precautions are set down to be rigidly observed:**

Inspect frequently in the magazines; in case of rust spots, have projectile scraped and repainted as before, with a thin hard paint.

Never disassemble any part of a loaded projectile without explicit instructions from the Ordnance Bureau.

Never remove a fuse from a loaded projectile without such instructions.

In handling use extreme care that rotating bands do not become dented or marred.

In handling five- and six-inch projectiles, which are fitted with rope slings to facilitate handling, see that these are kept intact and shells stowed in them.

The **trajectory** of a projectile is its path in the air between the muzzle of the gun and its target. As can be easily seen, the flatter this trajectory, or the longer the arc described by the projectile, the better will be the aim and the greater will be the velocity of the projectile on striking or impact.

In this connection the angle of impact of any projectile, in order that it be properly effective, should never be greater than ten degrees from the horizontal.

FUSES FOR PROJECTILES

A **FUSE** is a mechanical device or contrivance which, as has been already stated, is **located in every projectile and serves to ignite the bursting charge in that projectile when the projectile strikes a solid object in flight or at some predetermined time during its flight.**

Fuses are first divided into two general classes: **base** fuses and **nose fuses.**

BASE FUSES are those that are located in the base or rear of the projectile. **Every fuse is a base fuse except those used in shrapnel.**

NOSE FUSES are located on the nose or forward point of a projectile, a section of the point being cut away and the nose fuse screwed into its place. **Nose fuses are found in use only on shrapnel shell.**

Base fuses are now subdivided into two particular classes: detonating or delayed-action fuses and **simple ignition or impact** fuses.

SIMPLE IGNITION OR IMPACT FUSES are designed to explode on impact of the projectile or the instant the projectile in its flight strikes its objective or some solid object.

The use of ignition fuses is restricted at present to common shell or to projectiles that contain only black powder as a bursting charge. They act practically instantaneously on impact.

The finished fuse is in the form of a small cylindrical brass or bronze case, the after end of which is threaded; the fuse is screwed into the center of the base plug by means of this thread. It may be also mentioned that the thread is left-handed to prevent the fuse from screwing out as the projectile revolves clockwise in its flight.

PRINCIPLE OF ACTION OF SIMPLE IMPACT FUSE. This principle applies in general to any fuse, but essentially to one of the simple ignition or impact type. There are also several different designs invented by different men all of which vary in some details.

Every fuse must contain a firing-pin or plunger; a fulminate of mercury percussion cap; a charge of powder, usually black powder; and some device to lock the fuse from exploding at all times except when the projectile actually strikes during its flight.

The fuse described contains a small charge of black powder in its forward part. To the rear of that is a fulminate of mercury percussion cap. A firing-pin or plunger is centered in the fuse in rear of the center of the percussion cap and is locked or closed from any contact with it. **A centrifugal locking nut** is used to lock the fuse and projectile from exploding.

When the projectile is fired from the gun and when in flight it has attained a certain number of revolutions per minute, the arms of the centrifugal locking nut fly out and a hole in the center of the locking nut is exposed. The firing-pin, located directly in the rear of the center of the locking nut is thus uncovered. While the firing-pin is ordinarily free to move back and forth in its seat, the onward motion or impetus of the projectile keeps it back in its seat by inertia. **The instant, however, that the projectile strikes and stops, the firing-pin continues to go forward by its own momentum, and strikes and explodes the percussion cap.** The spark from this ignites the black powder charge, which in turn shoots forward a flame which ignites and explodes the bursting charge in the projectile. The action is almost instantaneous.

A **DETONATING OR DELAYED-ACTION FUSE** is used essentially in armor-piercing projectiles. It is called **detonating** because of the detonating or disruptive, violent nature of the explosive with which the projectile is loaded and which the fuse ignites. It is called **delayed-action** because of a device in it which permits the projectile to pierce the armor plate before the fuse ignites the bursting charge in the projectile, which thus causes the projectile to detonate or fragment on the inside of the armor plate and vessel, attended with considerable destruction. The action of a fuse of this type has already been gone into in

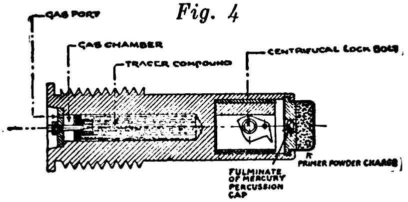
considerable detail in connection with the description of armor-piercing projectiles.

Another classification for base fuses is as " internal " and " external " types.

An **external** fuse is one that is screwed into the center of the base plug of a projectile and **is visible from the outside.** Simple ignition fuses are all of the external type.

An **internal fuse** is used only with armor-piercing projectiles. It is located in a hemispherical cavity in the inside face of the base plug and is **therefore inside the projectile and is not visible externally.** Both of these types of fuses have been referred to and explained before in connection with armor-piercing projectiles.

Fig. 4



External Base Fuse — Simple Ignition Type Equipped with Tracer Element

TRACERS AND TRACER FUSES are used on most projectiles and on all armor-piercing projectiles, to enable the flight of the projectile to be followed by eye during night firing. The device was invented by a man named Semple, and it is therefore often referred to as a **Semple tracer fuse.**

A tracer fuse is one that combines in the same bronze fuse case, a tracer element. This is in the rear part of the fuse. When the projectile is fired, the propelling gases ignite the tracer element, and, **as the projectile travels in its trajectory it leaves behind it a trail of light caused by the burning of the tracer compound, a slow-burning powder or chemical composition. Tracer fuses** are only those of the external type, inasmuch as the tracer element must be exposed at the base of the projectile to enable its ignition by the propelling charge of powder behind the projectile.

Where, as in the case of armor-piercing projectiles, we have internal fuses, the tracer is separated from the fuse itself. The fuse, as stated before, is inside the projectile. **The tracers (not tracer fuses)** are two in number. They

are long and cylindrical in shape and are located in the base of the projectile, just outside of the circumference of the base plug, in holes diametrically opposite or 180 degrees apart. These holes are large enough to permit the tracers to be slipped into them by hand, and the metal of the projectile is upset slightly over the end of the tracers when they are seated, to prevent them from falling out as the projectile flies forward. The tracers are ignited in the same manner as was the tracer fuse: by the action of the propelling charge of powder which expels the projectile from the gun.

NOSE FUSES, as stated before, are used only in shrapnel, and there is in use at the present time only one distinct class of these fuses, called **combination time and percussion fuses.**

COMBINATION TIME AND PERCUSSION FUSES are invariably located in the point or nose of a shrapnel shell. **Their aim is to explode the projectile while it is still in the air and after it has been in flight for a definite number of seconds; this is the time element. Failing in this, the fuse causes the projectile to explode on impact; this is the percussion element.**

Shrapnel shell is used against personnel or exposed bodies of men. To have its greatest effect, it should burst and its load of small shell should fly forward when it is still fifty yards from its target. This is accomplished by the time element.

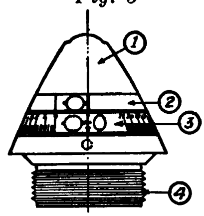
Inside the fuse, encircling its inner wall is a **ring or train of compressed slow-burning powder.** The rate at which this powder will burn, or the time that it will take a definite length of it to consume, is definitely and accurately known by tests. **On the outside of the fuse are two graduated metal rings.** One of these is movable and is graduated in "second" divisions from zero to 21 seconds as a rule, but sometimes to only 15 seconds. Each second division is further graduated into five equal parts, each representing one fifth of a second. **The division of time to which this graduated ring is set determines or limits the amount of**

the compressed powder train that will burn and consequently determines the time of explosion of the projectile.

Each fuse contains, in addition to the above, a **fuse-magazine**, which is a small amount of loose, quick powder. This is communicated with and set off when the compressed-powder train has burned to the amount "set." The explosion of the powder in the fuse-magazine sends the spark down the powder-lined stem of the projectile and directly explodes the bursting charge.

Before the projectile is loaded into the gun the graduated time ring is set so that the fuse will go off when the projectile is fifty yards in front of the target. The proper setting is figured out in advance from the known rate of burning of the fuse powder train and the known "feet per second velocity" of the projectile. This operation is called "setting" or "cutting" the fuse. **Suppose the fuse is "set" for "ten seconds" before being loaded into the gun. When the gun is fired, the powder time-train is ignited by a spark from an ordinary percussion cap and primer device** which is struck by a plunger or firing-pin that is released by the shock of the explosion of the propelling charge in the gun. **The powder time-train is therefore ignited as the projectile leaves the gun and continues burning at a uniform rate while the projectile is in flight.** When it has burned for "ten seconds" or practically half around to the division at which it was set, the powder train is "cut off" and the flame diverted to the fuse-magazine, which explodes and sends the flame down the powder-lined stem of the projectile and ignites the bursting charge in the base. This explodes the projectile. If the fuse was properly set, this explosion would take place about fifty yards in front of the target.

Fig. 5



COMBINATION TIME AND PERCUSSION FUSE. FANKFORT ARSENAL 21-SECOND

1, Fuse head; 2, Fixed ring; 3, Graduated and movable ring; 4, Threads into shell.

If, because of faulty or miscalculated setting, the **fuse does not explode the projectile during flight, there is in the fuse a percussion element, somewhat similar to that in a base impact fuse, and this operates to explode the projectile on impact or when it strikes.**

The time fuse in general use in the Naval Service today is put up in the " Frankfort Arsenal " and is called the **Frankfort Arsenal 21-second combination fuse.** A **Frankfort Arsenal 15-second combination fuse is also used** for special purposes.

Chapter XII

AMMUNITION — PRIMERS

FIXED; SEMI-FIXED; AND SEPARATE AMMUNITION — AMMUNITION CONTAINERS — COMPOSITION OF AMMUNITION — PRIMERS — TYPES OF PRIMERS AND THEIR ACTION

AMMUNITION is the term applied to the entire charge placed in the gun. It includes the projectile, powder, and primer in the case of separate ammunition, and the cartridge in the case of fixed ammunition.

FIXED AMMUNITION is ammunition wherein the powder charge, the projectile, and also the primer are all contained in one metallic (brass) cartridge case. The entire charge is placed in the gun chamber in one piece. Ammunition of this character is used only in rapid-fire guns of three- and four-inch calibers; also in 1, 3, and 6-pounders.

SEMI-FIXED AMMUNITION is similar to fixed ammunition. **The only difference is that the projectile is not fixed in the cartridge case. The powder and primer are both fixed in a cartridge case as in fixed ammunition.** Ammunition of this character is used only in rapid-fire guns of five- and six-inch calibers. The reason for it is that for these calibers, a cartridge containing the projectile in addition would be too heavy and awkward to handle and load with facility.

SEPARATE AMMUNITION is ammunition wherein the powder charge, projectile, and primer are all separate. Ammunition of this character is used only in Breech-Loading Rifles, usually of five-inch caliber and above. The

powder charge is contained in silk bags which are placed in the gun chamber to the rear of the projectile in loading. The primer is separate and is placed in the firing lock mounted on the breech mechanism of the gun.

PRIMERS will be discussed at length later. For the present, in order to give a clearer understanding of what follows, it will be sufficient to know that a **primer is a small device with the external appearance of a small arm, .30 inch caliber cartridge, and its function is to ignite the propelling charge of powder in a gun.** For this purpose it is equipped with a fulminate of mercury percussion cap and a small charge of explosive, either black or smokeless powder; also, most primers today are fitted in addition to permit of electrical firing.

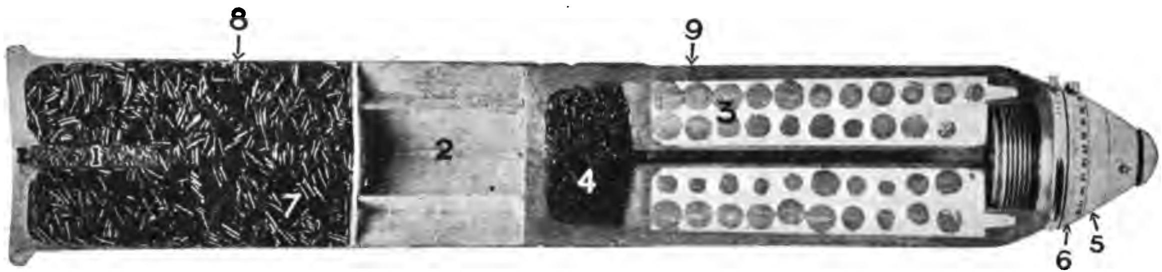
FIXED AMMUNITION

The **metallic cartridge cases,** that contain fixed ammunition for use in rapid-fire guns, are composed of brass, an alloy of copper and zinc. The case itself is a hollow cylinder with a flat head or base. The cylinder is shaped to fit the bore of the gun. The latest design of cartridge case has a bottle-neck; that is, the diameter of the case decreases rather abruptly several inches before reaching the projectile or the mouth of the case. This permits the powder chamber of the gun and the cartridge case to be larger in diameter than the rifled bore of the gun and the projectile. A powder chamber of equal cubical content is secured without utilizing as much of the length of the bore. A longer bore is given to the gun; consequently the projectile has greater muzzle velocity.

The **head or base of the case has a special rim or lip shaped to fit the extractor on the gun.** This facilitates the removal of the empty cartridge case from the gun after firing.

The case is drawn into shape from a disk of sheet brass, so there are no joints of any kind in it. The brass is a bright yellow and is very ductile and malleable in its composition.

Fixed Ammunition. Cross Section through Shrapnel Cartridge and Shell



1, Extension primer — loaded with a black powder ignition charge; 2, Distance pieces; 3, Small balls in shell — packed in rosin or sulphur; 4, Shrapnel-bursting charge; 5, Nose fuse; 6, Time ring of nose fuse; 7, Smokeless powder grains (loose) — propelling charge; 8, Cartridge case; 9, Projectile.

In the center of the base, there is a small hole bored to receive the primer. Some primers are driven or forced into position; others are screwed in. In the last case the hole in the case is threaded.

The **projectile is forced into the neck or mouth of the case and should be fixed securely in position. The rear edge of the rotating-band of the projectile fits snugly against the forward edge of the case.** When handling ammunition of this type, special care should be exercised to see that the shell or projectile is tightly in position. A loose shell brings about hang-fires in a gun.

The cases after being fired are carefully preserved as they can be refilled and used again.

The **POWDER CHARGE for fixed ammunition** for guns of three- and four-inch calibers is contained or put up in bags of special quality silk cloth, sewn with silk and laced with a raw-silk cord. The bags are approximately the same diameter as the cartridge case and a little shorter than the case in length, **so as to enable the whole bag to fit easily inside the case to the rear of the base of the shell or projectile.**

The bag is filled with grains of smokeless powder of the size corresponding to the caliber of the gun. The base end of the bag is made of two thicknesses of silk cloth and between these, which act as partitions, **is placed an ignition charge of black powder. This rear end of the powder bag is dyed a bright red in color, indicating that it contains the ignition charge, and should be placed next to the primer.**

Fixed ammunition is now being made for these calibers, three and four inches, where the smokeless powder is placed right inside the cartridge case loose, filling it, no bags being used. The powder is held in place by specially shaped pasteboard wads, called distance pieces. Where the powder is placed in the cartridge case in this manner **a special type of primer, called an extension primer, is used.** This is exceptionally long and extends well into the powder charge. A quicker ignition and explosion is brought about by its use. **Where this manner of loading a case is utilized no**

ignition charge is necessary, the black powder charge in the primer being sufficient to bring about ignition of the smokeless powder.

For 1-pounder, 3-pounder, 6-pounder, and three-inch landing pieces the powder charge is placed in the cartridge case, no bags being used. The ignition charge is in the primer and the powder is kept in position in the case by pasteboard wads and distance pieces, consisting of criss-crossed pasteboard strips.

SEMI-FIXED AMMUNITION

In semi-fixed ammunition the powder and primer are fixed together in a brass cartridge case in identically the same manner as has been described for fixed ammunition. The **projectile, however, is separate from the cartridge case.** This semi-fixed ammunition is used in rapid-fire guns of five- and six-inch calibers. The reason for it is that for five- and six-inch calibers, to have the whole charge, including the projectile, in one case would make it unwieldy and too heavy for one man to handle with facility.

Rapid-fire guns, it must be kept in mind, make possible a more rapid fire than guns of the B. L. R. type, and this is the reason for making rapid-fire guns in five- and six-inch calibers, necessitating semi-fixed ammunition.

SEPARATE AMMUNITION

Separate ammunition, as has been already stated, consists of a projectile and a separate charge of powder contained in bags; also a separate primer.

POWDER BAGS. As was the case with fixed ammunition where the powder charge was placed in the cartridge case in a bag, **the bags which contain the powder for separate ammunition are manufactured of a special quality of silk cloth,** are sewn with silk, and are laced up with a raw silk cord. The lacing goes into flaps on the sides of the bags

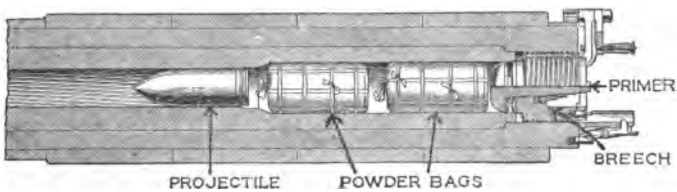
and is for the purpose of tightening the bags as the material stretches.

At the ignition end of the bag there are two thicknesses of cloth with the black powder ignition charge in quilted divisions between them. The outside cloth forming the ignition end is cut from cloth that has been dyed red.

At the other end of the bag a stout strap of cloth is fastened for the purpose of handling the bag during loading.

SIZE OF POWDER BAGS is approximately as follows:

For a twelve-inch caliber gun the bag is approximately twelve inches in diameter and from eighteen to twenty inches long — **four bags of powder this size constitute a propelling charge for a twelve-inch projectile.** For all



SEPARATE AMMUNITION — LOADED IN GUN
7- to 10- inch caliber

calibers above this four bags are used, the individual bags, of course, increasing in size proportionally with the caliber of the gun.

For guns of calibers from seven to ten inches inclusive, two powder bags are used, each bag being in diameter approximately the same as the caliber of the gun and in length from sixteen to twenty inches.

For guns of five- and six-inch calibers, one powder bag is used. In diameter it is approximately the same as the caliber of the gun and in length between two feet six inches and three feet.

TAGS ON POWDER BAGS. To each bag containing a charge or part of a charge of powder, a cloth tag is attached giving the following information:

1. Caliber of gun for which intended
2. Proportion of charge contained

3. Weight of charge
4. Index of smokeless powder contained
5. Amount of ignition powder contained
6. Name of magazine at which powder was put up, with date
7. Initials of inspector in charge of above magazine
8. Initial velocity given by full charge

In addition to the foregoing the bag is stenciled to give:

(1) Caliber
(2) Mark of gun
(3) Charge (such as full, $\frac{1}{2}$; $\frac{1}{4}$, etc.)
(4) Weight of charge
(5) Initial velocity
(6) Initials of inspector
(7) Number of grains of ignition powder

POWDER TANKS. All powder bags containing smokeless powder or propelling charges are stowed inside of specially constructed cylindrical galvanized steel or copper tanks, which are air-tight. These tanks are made as strong and at the same time as light as possible to enable quick and easy handling. The sides of the tanks are protected by long strips or battens of wood. The covers are of special design, so that they will open quickly and easily and at the same time be air-tight. The tanks have handles at the sides and top.

The purpose of the tanks is first of all the protection of smokeless powder from the effect of the atmosphere. Secondly, it permits of easy stowage and is a protection to the integrity of the bag itself; also it keeps the powder bags clean and ready for instant use.

Before using powder tanks for stowage of powder, they should be carefully examined for cleanliness and dryness. All dents should be hammered out and soldered and every test made to insure the tanks being air-tight.

The **arrangement of powder bags in tanks** is as follows:

12-inch caliber and above:

Two tanks and four powder bags to a charge. Two bags in each tank.

10-inch to 7-inch calibers, inclusive:

One tank and two powder bags to a charge. Two bags in one tank.

5- and 6-inch calibers:

One tank and one powder bag to a charge. One bag in one tank.

MARKING POWDER TANKS. Each powder tank containing any part of a powder charge is painted around the top of the tank with a circular white band, two inches wide. On this white band is stenciled in black letters, $\frac{3}{4}$ of an inch high, the index number of the powder and the caliber and mark of the gun for which intended.

If the tank contains any part of a **reduced charge**, the letters **R. C.** are stamped in addition to other information on the white band.

PROJECTILES for both separate and fixed ammunition have been fully treated under the discussion devoted exclusively to this subject.

The **WEIGHT OF A POWDER CHARGE** for the various sized projectiles has been computed to be 36% of the weight of the projectile. That is, for a projectile for a twelve-inch caliber gun, of weight 870 pounds, a charge of smokeless powder weighing 36% of 870 pounds is necessary to secure desired muzzle velocity.

AMMUNITION BOXES are made of poplar wood, with a becket at one end, the cartridges being held by corner wedges, and one side of the box being easily removed.

All fixed ammunition is boxed; the painting of the exterior of the box indicating the character of the projectiles contained. Painting is as follows:

Armor-piercing	All black
Common shell	All lead color
Shrapnel	All white
Blind or target	All red

Fixed ammunition is boxed according to the size of the cartridges as follows, and is stowed in boxes:

For 4-inch and 5-inch guns	1 cartridge to box
For 3-inch 50-caliber gun	4 cartridges to box
For 3-inch landing gun	6 cartridges to box
For 6-pounder gun	11 cartridges to box
For 3-pounder gun	16 cartridges to box
For 1-pounder gun	60 cartridges to box

Boxes containing **saluting charges** are painted **lead color, with top of box half red and half white.** The box is marked on top with black letters. Saluting charges are made up of black, pea-shaped, black powder.

Boxes containing **signal charges** are painted **light blue.**

Boxes containing **drill cartridges** are painted **half black and half white**, with white and black letters.

Boxes containing **fixed ammunition loaded with explosive " D "** have **cover** of box (edges and top) painted **yellow.**

Tags on ammunition boxes contain practically the same information as that listed for powder bags, and in addition the character of the projectile and bursting charge.

SERVICE AMMUNITION is part of a ship's battle equipment and is for use only in battle. It shall never be expended at target practice except by explicit directions of the Bureau of Ordnance; nor shall it be used at drill, for instruction; testing hoists or for any other purpose. It must be kept intact, as issued.

TARGET-PRACTICE AMMUNITION is used only in target practice. It shall not be retained aboard for long periods; shall be kept distinct from service ammunition and shall not be used for drill purposes.

DRILL AMMUNITION for rapid-fire guns consists of a dummy cartridge of regulation size. The body of the cartridge is wood, the base of steel with regulation lip to permit of frequent extraction from loading machine. The projectile is of cast iron.

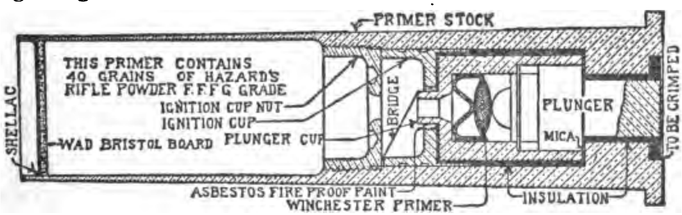
For B. L. R.'s a cast iron or brass projectile is used and canvas bags of beans of the same size as the powder bags for that caliber gun.

PRIMERS

A **primer** is a specially constructed device or contrivance, the flame from which, when it is exploded by the direct action of the firing mechanism of the gun, ignites the powder charge in the chamber of the gun and thus causes the gun to fire.

In **rapid-fire guns, the primer is screwed or driven into a recess in the base of the metal cartridge case containing the powder.**

In **breech-loading rifles or separate ammunition guns, the primer is seated,** after the gun is otherwise ready to fire, **in a firing lock,** mounted on the end of the mushroom stem of the breech mechanism. On explosion of the primer, its flame travels down a vent or hole in the center of the mushroom stem to the propelling charge of smokeless powder, igniting it.



COMBINATION PRIMER — B. L. R. GUN — ELECTRIC AND PERCUSSION TYPE

PERCUSSION PRIMERS are those primers that are **fired by the impact of a firing-pin or hammer on a percussion cap** containing a very sensitive explosive, such as fulminate of mercury. The spark from the explosion of the cap ignites the primer charge of rifle powder, which shoots forward and ignites the propelling charge of powder in the gun.

Percussion primers are now made and fitted only to fixed ammunition for rapid-fire guns of 3-inch caliber and below. Percussion primers are the only ones used in these guns.

COMBINATION ELECTRIC AND PERCUSSION PRIMERS are those that combine in one case the properties

of a percussion primer as well as the property of firing by means of an electric current.

Where the electrical attachments and connections are in proper working order the electric ignition is used; the percussion element is for use only as an alternative in the event of failure of the electrical system.

Breech-loading rifles or separate ammunition guns use only combination primers.

ACTION AND DESCRIPTION OF A COMBINATION PRIMER

The primer case is made of bronze. It is cylindrical in shape and about two inches long. The **percussion element** consists of a small plunger centered in the base of the primer case; a fulminate of mercury percussion cap; and a primer firing charge of about 40 grains of rifle powder in the lower part of the primer case. The **electrical element** consists of a fine platinum wire passing through a cavity filled with rifle powder, one end of the wire being connected to the primer case. A fine wisp of dry gun-cotton is wound around the platinum wire. An ebonite bushing is also provided, and surrounds the percussion element, insulating or cutting it off from the electrical current passing through the primer case.

Firing by electricity, the gun pointer presses the firing-key in the handle of his operating wheel. If the breech is closed and locked, this causes the connections to be established. Current passes through the firing connections, through firing-pin in the firing lock, and thus through the primer-case, the point of the firing-pin resting on the primer when the breech is closed. Passing through the primer case and around the ebonite bushing or insulator, the current heats to red or white heat the platinum wire. This causes the explosion of the gun-cotton around the wire, and the spark from this ignites the powder in the cavity and the primer charge, the flame from the primer charge shooting through the vent in the mushroom-stem and firing the gun.

Firing by percussion in the event of failure of the elec-

trical system, the hammer on the firing lock is tripped by a lanyard. The hammer jumps forward, causing the firing-pin to strike the plunger in the base of the primer. The plunger is forced forward against the fulminate of mercury cap, a spark being generated which ignites and explodes the primer charge, firing the gun.

EXTENSION-MAGAZINE COMBINATION PRIMERS. Primers of this nature are used only with fixed and semi-fixed ammunition of from 4- to 6-inch calibers, inclusive.

The primer case is exceptionally long and contains an unusually large charge of powder as a primer charge. **The charge consists usually of 270 grains of fine grain black powder.** The primer case screws into the base of the cartridge case, but in all other respects it is identical with the B. L. R. combination primer described above.

In all cartridge case ammunition it is increasingly the practice to load the powder grains into the case itself loose, without utilizing a bag. No ignition charge is provided, so it is included in the primer case, and the case is made exceptionally long so that the black powder will go off while practically centered in the rear part of the smokeless powder charge and so bring about a quicker explosion of the propelling charge.

Detonators for mines and torpedo war-heads are practically primers of a special type, and in principle they are the same as primers.

They bring about ignition of the exploding charge in the torpedo war-head or mine. **Their function is a combination of the functions of a primer and a fuse.**

Mines and torpedoes are loaded either with wet guncotton or cast TNT; in the first case the detonator is composed of dry cotton and in the second of granular TNT.

CHAPTER XIII

MAGAZINES

STOWAGE OF POWDER AND PROJECTILES — VENTILATION, REFRIGERATION, AND LIGHTING OF MAGAZINES — FLOODING AND DRAINAGE — AMMUNITION HOISTS

MAGAZINES are specially constructed water-tight compartments of a ship, in which all powder, explosives, projectiles, and ammunition are stowed, the only exceptions being dry gun-cotton and detonators for torpedoes. These are extremely sensitive and are therefore stowed above the water line, where they can do least damage in case of explosion. **Magazines containing " projectiles " of any caliber are referred to as shell-rooms.** A few projectiles are often stored in gun racks below decks and in turrets for use in case of emergency.

A magazine compartment is designated according to its contents and also according to its location in the ship. The magazine compartments are numbered as to location, the same as any other compartment of the ship, but have in addition to the regular number, the capital letter " M ", indicating that it is a magazine; *i.e.*, A–37–M would be a magazine compartment, forward on the starboard side of the lower deck. A–5 would be an ordinary compartment, forward on the starboard side of the lower deck, probably a store-room. D–37–M would be a magazine aft, starboard side lower deck. Referring to a magazine by its contents you would say, " six-inch powder magazine " or " six-inch shell-room ", followed by the compartment number.

FLOODING AND DRAINAGE — FLOOD-COCKS

As was stated above, all magazines are water-tight compartments, so that in case of emergency, such as a fire, it is possible to flood any magazine, or group of magazines, without unduly endangering the entire vessel, the flood water being kept confined to the limits of the particular magazine or magazine compartments, until the inflammable contents are thoroughly drenched. The water is then drained off.

Magazines are flooded by sea water. Those below the water line have flood pipes leading from a valve in the ship's side below the water line, called a sea-valve. Those above the water line have flood pipes leading from the ship's fire main. **The flood pipe in shell-rooms is a simple pipe with one opening. In magazines the flood pipe has a number of small holes in the under side after the manner of a sprinkler,** so as to make it possible to drench a large amount of powder in a short time. **A magazine flood pipe is often referred to as a sprinkler.** Sprinklers are also fitted over gun-loading positions in turrets and over powder-loading positions in handling rooms.

The requisite of every flood pipe and every magazine flooding system is that any magazine must be able to be completely flooded in twenty minutes.

In new dreadnoughts, instead of each magazine and shell-room being flooded separately, they are divided into groups and flooded by groups, by turning one valve. Each magazine is fitted with a cut-out valve, so that the whole group or any certain compartments in a group may be flooded.

FLOOD-COCKS are the connections or valves by which the flooding system is turned on. On most ships in the Service, including **battleships of the pre-dreadnought type, a spindle connection leads up to the berth deck from the flooding pipe in each magazine compartment.** These spindles end in square sections just below the berth deck and a small, round, brass deck plate covers the end of the spindle. When the magazine is to be flooded, a large key or wrench is shipped **on to the end of the spindle, and turning this causes flooding.**

The deck plate at each flood-cock gives the name and number of the compartment that it floods. This information is also contained on a plate attached to the beam overhead and above the flood-cock.

Flood-cock wrenches are kept in a locked rack, the keys of which are in the custody of the commanding officer. In some cases, instead of the wrenches being kept locked, the deck plate over the head of the spindle is locked with a padlock, the key of which is kept in the cabin. In either case, the object is to prevent any tampering with the magazine flooding system, and to insure that any flooding done, is done with the knowledge and consent of the commanding officer.

When a magazine is flooded, the air escapes as a rule through the exhaust ventilator, located in the top part of the magazine; if there is no exhaust ventilator, a special **escape-valve** for the air is fitted. This is the case on dreadnoughts where magazine refrigeration only is used. Compartments flooded from the fire main, or those above the ship's water line, have **relief-valves** to prevent the accumulation of an air pressure that might cause the bulkheads to collapse.

DRAINING MAGAZINES is necessary after they have been flooded for a prescribed length of time. Ammunition-rooms in the hold (below the water line) have drain pipes leading direct to the ship's bilges, from each of which suction pipes lead to drain-manifolds for the purpose of pumping water from the bilges. Upper compartments have individual drain-pipes to bilges or to lower compartments; thence to the bilges.

Recent ships (dreadnoughts) have no means of draining magazines and shell-rooms provided, other than by portable pumps.

TESTING FLOOD–COCKS is required by Naval Regulations to be done once each week by the Gunner (warrant officer) of a ship, and the result of the testing to be entered in the ship's log. For testing purposes the flood pipe in each magazine is fitted with a small test-cock. In the weekly testing a bucket is held under this test or drain cock. If

water comes with sufficient force, the system is in proper order.

MAGAZINE VENTILATION

Good magazine ventilation requires a complete change of air in every ammunition compartment once in every eight minutes.

Proper ventilation in magazines is especially necessary where the contents are smokeless powder. A large proportion of smokeless powder composition is volatile liquids which have a tendency to return to vapor. The ether fumes from smokeless powder are very inflammable and must be carried off; also the powder must be kept cool to preserve it.

The system of ventilation most generally in use in Naval vessels consists of a supply of fresh air direct from the ship's artificial ventilating system, to each magazine compartment, and an exhaust ventilating duct of greater area than the supply duct and as far away from it in the compartment as possible. The fresh air is drawn by means of blowers from the open air and is sent through the ventilating system or ducts to each magazine.

An improved system of ventilation is in use on a number of battleships of the pre-dreadnought type, wherein the fresh air supply before being admitted to the magazine is passed over cooling-coils in cooling-boxes located outside each magazine or group of magazines. This system, in addition to supplying fresh air, regulates magazine temperatures.

REFRIGERATION OF MAGAZINES to replace the ventilating system is now accomplished on battleships of the dreadnought type by the use of an ethyl-chloride ice-machine, by means of which cold brine is circulated directly to the magazines and through piping in each magazine. Magazines are fitted with drip-pans to protect the powder from possible leaks in the piping, etc. **This system of magazine refrigeration has proved satisfactory, and where it is used no artificial ventilation of the magazine is provided.** Where refrigeration is employed the decks and bulk-

heads of the magazine are well insulated with sheet cork from two to three inches in thickness.

The **TEMPERATURE** in magazines should never be consistently over 80° F. Original temperature requirements called for 70° F. as a maximum, but recent experience has shown 80° F. to be satisfactory, and it is at this average temperature that most magazines are actually kept. If the temperature should reach 90° F., artificial means of reducing it should be resorted to. **If the temperature in a magazine containing smokeless powder should ever rise to 100° F., a special report covering all circumstances must be made immediately to the Bureau of Ordnance.**

LIGHTING OF MAGAZINES

Naval Regulations require magazine lights to be contained in water-tight cases or lanterns and to be of such a nature that they will burn continuously for at least four hours; also that the lenses of the lantern or light box be clean and without fracture.

On most naval vessels, including battleships of the predreadnought type, each magazine and shell-room is lighted by one or more light-boxes, of standard navy pattern, which throw light in three directions through round ports covered with double glass plates. **The boxes are water-tight, and are separate compartments opening only from the deck above or from the outside of the magazine.** Each light box contains an incandescent lamp which is connected up on the **magazine circuit.** This circuit is used for no other purpose than magazine lighting. Light-boxes are equipped with candles for auxiliary lighting.

On battleships of the dreadnought type, magazines and shell-rooms are now lighted by bunker lights or heavy electric lanterns, hung up or supported from the bulkhead on the magazine side.

MAGAZINE LOCATION AND ARRANGEMENT

Magazines are located, wherever possible, below the water line of a ship, and always in a position protected by the ship's armor belt.

The second requirement is that each magazine and shell-room be located as near as possible to the guns of the battery that it supplies, — this to avoid delay and confusion in supplying ammunition during an action.

Taking, for example, a battleship of the pre-dreadnought type, we find the 12-inch magazines and shell-rooms leading directly from the lower handling room of each turret. This is an ideal arrangement, permitting of a rapid and constant supply of ammunition.

On these ships there is also what is called a "**wing or ammunition passage**", on each side of the splinter deck, extending all the way fore and aft. The broadside battery gun ammunition hoists (where they cannot be led direct from the magazine) lead to the gun deck from this passageway, which is equipped with overhead trolleys for the rapid handling of projectiles. These passageways are also utilized in transporting 12-inch turret gun ammunition from one handling room to another in case of emergency.

Ammunition of only one caliber is stowed in each magazine; that is, all 6-inch powder is stowed in magazines by itself; all 12-inch powder in separate magazines, etc.

It is also endeavored to locate magazines and shell-rooms for the same caliber ammunition, adjacent or as nearly so as possible.

In dreadnoughts, owing to the distribution of the turrets, the magazine location is more complicated, but the general principles outlined in the foregoing are adhered to as closely as possible.

In the new 14-inch gun super-dreadnoughts, projectiles for the turret guns are stowed (base-up) in the turret itself and inside the barbette. The magazines open from a powder handling room, below the turret.

AMMUNITION STOWAGE IN MAGAZINES

Projectiles are stowed in bins, on their sides, bases all facing in same direction. The axes of the projectiles are placed fore and aft, where possible, and chocks or blocks are placed between them, so that they will not roll from side to side due to the rolling motion of vessel. **Projectiles are always stowed in separate compartments or shell-rooms.**

Powder tanks containing smokeless powder are stowed on their sides (never on end) in specially constructed bins or stages. They should be stowed on each side of the magazine with a passageway between. **The heads of the tanks should all face the passageway, so that the contents of any tank may be removed without disturbing other tanks.** Stowage of powder is done with a view to supplying powder to the ammunition hoist with greatest facility. Tanks, in the same manner as projectiles, and for the same reason, should be stowed parallel to the keel rather than athwartships.

Smokeless powder for each caliber is stowed in separate magazines.

Black powder, except ignition charges made up in smokeless powder bags, is stowed in a separate magazine.

Fixed ammunition is stowed in separate magazines.

Small-arms ammunition is stowed in separate magazines.

Wet gun-cotton charges for torpedo war-heads, mines, etc., are kept in special steel boxes, stowed in a specially constructed compartment in the hold of the vessel.

Dry gun-cotton primers, etc., are stowed above the water line. All dry gun-cotton is kept in glass jars above the water line and removed as far as possible from the vital parts of the ship; also out of the sun.

Detonators for torpedoes, etc., are stowed above the water line, out of the sun; usually in the " top " in a specially constructed steel box.

AMMUNITION SUPPLY HOISTS

Ammunition (projectiles and powder) for broadside battery guns is supplied to the guns from the magazines and

shell-rooms by ammunition hoists. In general principle, a hoist consists of two endless sprocket chains, similar to a bicycle chain, one on each side. Between the chains, at every three or four foot interval, is supported a small tray, which moves in complete revolution around the hoist. In the magazine, there is a large loading tray. Every time one of the small trays, on its upward course, appears on a level with the loading tray in the magazine, a man standing by with projectile or powder tank in hand places it, base end down on the small tray, which carries it upward. On reaching the deck, or top of the hoist, the ammunition is removed by a tender just before the small tray turns and starts on its downward trip.

Turret ammunition is necessarily handled in a different manner, due to its bulk and weight. These hoists have been covered under "Turrets and Turret Machinery."

PRECAUTIONS TO BE OBSERVED IN CONNECTION WITH MAGAZINES

Points to Be Remembered

1. No naked light shall ever be taken into a magazine.

2. Matches shall never be carried into a magazine.

3. Magazines are never to be opened without the knowledge of the Commanding Officer, and the keys are to be kept in the custody of the Commanding Officer at all times.

4. Keys to the flood-cock wrenches are also to be in the custody of the Commanding Officer.

5. Magazines shall be inspected daily by the Gunner (warrant officer) of a ship, under the supervision of the Ordnance Officer, when all temperatures shall be taken and the state of ventilation noted. The result of this inspection, and maximum and minimum temperatures, shall be entered in the ship's log.

6. All magazines and shell-rooms shall be inspected weekly by the Gunner, when all flood cocks and ventilating apparatus and safety devices shall be tested, the result being entered in the log.

7. Magazine doors shall be kept closed at all times.

8. When magazine doors are open, all naked lights outside the magazine but in the vicinity shall be extinguished at discretion of Commanding Officer.

9. During firing no ammunition other than that immediately required shall be permitted to remain outside the magazines.

10. The magazine flap-doors of only such magazines as are being used to supply charges shall be open, the flaps in all cases being down except during the time of actual passage of the sections of the charge through the door.

11. There shall not be exposed (removed from the tanks) at one time, in any one magazine, more than one charge for each turret gun supplied by that magazine, and then only as necessary to supply the demand in the turret handling room; nor shall there be permitted at any time an accumulation of exposed sections for more than one charge for each ammunition hoist outside the magazines in the handling room.

12. Smokeless powder shall be stowed in magazines by itself; for different caliber guns being stowed separately if possible.

13. Small-arm ammunition shall be stowed in a separate magazine.

14. Powder and projectiles must be stowed separately.

15. Black powder, except ignition charges, shall be stowed separately.

16. Fixed ammunition shall be stowed separately.

17. Smokeless powder of different indexes shall be stowed in separate magazines.

Chapter XIV

AMMUNITION

INSPECTIONS AND TESTS

INSPECTIONS AND TESTS REQUIRED BY NAVAL INSTRUCTIONS — VISUAL, VIOLET PAPER, AND SURVEILLANCE TESTS — TESTS OF SMOKELESS POWDER, GUN-COTTON, AND TNT, ETC.

All ammunition, and especially smokeless powder, must be frequently and carefully inspected and tested in the magazines to insure its proper maintenance in an efficient state.

Smokeless powder being an ether-alcohol colloid of nitrocellulose, cannot be held to possess unlimited chemical stability, **and the length of its life, therefore, depends largely on the conditions under which it is stored. At temperatures approaching 100° F. the period during which it will retain stability sufficient to warrant its retention in service is relatively short.** By means of chemical tests an indication only of the probable life of the powder can be secured. **Therefore, the only practical safeguard is to discover loss of stability by frequent tests and inspections.** Naval Instructions requires that the tests outlined in the foregoing be made with unceasing care and vigilance.

Officers charged with the care of magazines and the examination and tests of smokeless powder are required to thoroughly familiarize themselves with the practical methods of making such examinations and tests, and they are held responsible for the accuracy of the tests and the official reports covering them. **The tests must, in every detail, conform with**

prescribed methods, in order that the results, as indicating the stability of the powder, may be of value.

The Bureau of Ordnance records all tests reported from various sources, and keeps careful records of the disposition and condition of each index (each lot or mixture of smokeless powder grains as the last step in its manufacture). This makes it possible for proper steps to be taken, without delay, to dispose of any index which develops low stability. In order that this system may be carried out, correct and complete reports of stability tests, ammunition on hand, etc., must be submitted promptly.

The following tests and examinations, as outlined, are required by Naval Instructions to be made of smokeless powder on board ship. Each of these is later fully described.

1. **DAILY — Visual examination of samples and tests of charges for local heating. Examination of violet paper.**

2. **FORTNIGHTLY** (2 weeks) — **Visual examination of one or more charges of each index.**

3. **MONTHLY** — 65.5° **C. "surveillance" test on all indices that give a test of less than 30 days.**

4. **BI-MONTHLY** (2 months) — 65.5° C. **"surveillance" test on indices giving 30 to 39 days' test.**

5. **QUARTERLY** (3 months) — 65.5° C. **"surveillance" test on indices giving 40 to 59 days' test.**

6. **SEMI-ANNUAL** (6 months) — 65.5° C. **"surveillance" test on indices giving 60 days' test or more.**

DAILY EXAMINATION:

This examination of smokeless powder is made as a part of the daily magazine inspection required by the Regulations to be made by the "Gunner" (Warrant Officer) of a ship. **With all ammunition received on board from a shore magazine, there is supplied a small sample of each different index of powder.** These samples will be contained in a glass bottle with a tight glass stopper and shall never be opened, except for the purpose of conducting the violet paper test, which will be described later. **The different samples will be stored in the racks provided, in the same magazines with the indices of powder which they represent.** The samples shall be

examined daily in a good light, without removing the stopper, to note whether the powder retains its normal appearance. **The presence, at any time, of reddish or orange-colored fumes in the bottle will indicate the decomposition of the powder.**

Advance decomposition of powder is often accompanied by heat. Therefore several charges of each index shall be removed from the powder tanks daily and examined for evidences of heating by laying the bare hand on the surface of the bag.

FORTNIGHTLY (2 WEEKS) TEST:

The powder in one or more charges of each index shall be visually examined once in every two weeks for signs of decomposition or change in appearance. Different powder charges shall be selected from time to time for this examination, and, after marking them, particular pains shall be taken to see that the **tanks or powder cases, the contents of which are to be exposed for as short a time as possible, are restored to their former air-tight condition.**

The inside of a powder tank or bag containing smokeless powder which has been giving off **NITROUS FUMES, which accompany decomposition, will probably show a reddish or orange appearance.** Upon first opening such a package the characteristic **acrid and pungent odors of the nitrous fumes can be readily detected by smelling.** Upon this point depends the main value of this examination, and the conditions upon first opening the charge should be carefully noted, by placing the nostrils to the charge immediately after opening. **The odor of ether is natural and is of small consequence.**

A small scoopful of the powder should be taken in the palm of the hand and into a good light, and examined as to its physical properties. **Powder is of various colors, ranging from light yellow to dead black.** Certain indices have been dyed a **bright red,** which, in the course of time, will bleach; but this bleaching is not to be taken as an indication of decomposition. Other varieties will change color, darkening from the original yellow to brown or black. This indicates a certain change, but does not indicate loss of stability or change

in ballistic properties. **In general, no notice is to be taken of the color or change in color, except that a very marked whitening of the grains, in connection with other indications, is to be considered as indicating loss of stability. The grains of decomposing powder will, in a measure, become soft, yielding to the pressure of the thumb nail, or crumbling easily.**

VIOLET PAPER TEST

There is issued to all naval vessels a supply of **violet paper,** which has taken the place of litmus paper for powder testing. This paper is used dry at all times. It is called **N/10 Violet Paper**; is of rather a pale violet tint; and is used on ships for testing powder at normal atmospheric temperatures.

Smokeless powder being a nitro-cellulose product, is subject to decomposition at a rate which is largely influenced by temperature. If powder could be kept at a low temperature it could be considered permanently stable. At 60° F. the decomposition is so exceedingly slight that powder could be stored for many years without difficulty. At temperatures above 70° F. the rate of decomposition rises rapidly. **The result of decomposition is the giving off of "oxides of nitrogen" in the form of gases. These gases are strongly acid and have oxidizing properties which decolorize the violet paper.**

In the presence of oxides of nitrogen from decomposing powder the violet paper changes in color from violet, through blue, to white. The paper is not affected by other acids, diffused light, or ordinary handling. Care shall be taken, however, to keep it clean. When received, this paper shall be transferred to tight glass-stoppered bottles. The bottles shall always be stored in a dark place.

To test smokeless powder from rounds, charges, or in bulk, a portion of the sample, preferably about twelve ounces of powder, shall be placed in a sixteen-ounce glass-stoppered bottle. **One strip of the dry violet paper, marked in pencil with the date of starting the test, shall be dropped into the bottle on the powder, and the bottle tightly closed.** The

bottle shall now be stored in the magazine from which the sample was taken, preferably in the warmest part of the magazine. **The time of the test is the number of days required for the paper to become white, and the bottle shall not be opened during this time.**

Only one piece of this paper should be allowed in the test bottle at any one time. Total loss of color should be checked by examination in good sunlight and by comparison with prepared standards. These standards may be prepared by holding strips of the violet paper in red fumes formed by the action of dilute nitric acid on copper, which produces nitrous fumes similar to those given off by decomposing smokeless powder; or by exposing to the sun's rays a small quantity of small-caliber powder in a bottle until a slight odor of nitrous fumes is noticed, and then dropping a strip of violet paper in the bottle. Gradations of loss of color may be obtained in this way and the sample strips retained, without special care, for future use.

The daily examination calls for the examination of the violet paper, these violet paper tests being in progress continuously in every magazine containing smokeless powder.

SURVEILLANCE TEST

The surveillance test is required to be applied to one sample from each powder index, every six months. The sample, of fifteen to fifty grams in weight, shall be taken from a broken powder charge, the lesser weights being taken for the small-caliber powders. The sample is placed in an eight-ounce, salt-mouth, glass-stoppered bottle, made tight by grinding the stopper, and **then exposed in the bottle, in a 65.5° C. (150° F.) constant temperature oven. The bottle must not be opened during the test. The end of the test is the first appearance of red, nitrous fumes in the bottle, and the record to be made is the number of days which it takes to develop these fumes.**

Routine surveillance tests shall be started on July 1 and on January 1 of each year, and the results shall be reported

to the Bureau of Ordnance on proper blanks at their completion. **At the end of sixty days the tests shall be discontinued,** unless for particular reasons it is advisable to run it longer, and **any index which does not give red fumes within this period is to be reported as " sixty days +."**

On board ship when any powder gives off nitrous acid, red fumes, in a period shorter than given below, a special report shall immediately be made to the Bureau of Ordnance and three samples of the powder shall be immediately forwarded to the nearest naval magazine, for test, and with a statement of the circumstances.

16-Inch, 14-Inch, 50-Caliber	23 days
12-Inch, 45-Caliber; 10-Inch, 40-Caliber	21 days
12-Inch, 40-Caliber; 8-Inch, 45-Caliber	19 days
13-Inch, 35-Caliber; 12-Inch, 35-Caliber 7-Inch, 45-Caliber	18 days
10-Inch, 30-Caliber; 8-Inch, 35-Caliber 6-Inch, 50-Caliber; 5-Inch, 51-Caliber 4-Inch, 50-Caliber; Mark IX	17 days
6-Inch, 40-Caliber; 5-Inch, 50-Caliber 4.7- and 4-Inch, 50-Caliber, Mark VIII	16 days
All smaller	**15 days**

The examination of the bottles in " surveillance " ovens for red fumes shall be made once every twenty-four hours in a good light. The fumes, which will not be dense, and will be yellowish red, can best be seen by looking through the bottle at a white background. Should there be any doubt as to the presence of the fumes at a daily examination, the appearance should be carefully noted and a close examination made on the following day, when the additional twenty-four hours' exposure have very considerably increased the depth of color. **Upon the conclusion of the test, the sample shall be removed from the oven and thrown overboard, since it may explode if the test be carried too far.**

The test shall be conducted in an electrically-heated constant-temperature oven which is supplied for the purpose to all naval vessels of sufficient tonnage, and to groups or

divisions of small vessels. Full directions for the operation of the ovens are supplied with each outfit, and sealed tubes will be furnished as comparison tubes for determining the end of the test.

Sealing wax shall not be used on bottles. The object of the constant-temperature oven is to determine the length of time in which a given quantity of powder at a temperature of 65.5° C. (150° F.), when placed in air-tight, glass-stoppered bottles, will produce visible red oxides of nitrogen. Samples tested are made up of whole grains of smokeless powder, and will weigh 45 grams for all calibers except 10-inch, 40-caliber and above; five whole grains of these calibers will be used. The designation of the powder, and the date when put in the oven, should be written in pencil on the etched space on the bottom of the bottle.

MONTHLY; BI-MONTHLY; QUARTERLY AND SEMI-ANNUAL SURVEILLANCE TESTS

MONTHLY SURVEILLANCE TESTS are made on all indices of powder that, in the first routine semi-annual test, stay in the constant temperature oven at 65.5° C. (150° F.) for less than 30 days without decomposition setting in (giving forth red nitrous fumes). A test of thirty days for good powder is possible only for comparatively small-grained powder.

BI-MONTHLY SURVEILLANCE TESTS are made on all indices of powder that, in the first routine semi-annual test, stay in the oven at 65.5° C. only between 30 and 39 days, before decomposition sets in.

QUARTERLY SURVEILLANCE TESTS are made on all indices of powder that, in the first routine semi-annual test, stay in the oven at 65.5° C. only between 40 and 59 days, before decomposition sets in.

SEMI-ANNUAL SURVEILLANCE TESTS are the regular routine tests required to be made on all powders each July 1 and January 1, and they are made on all powders that in the previous test lasted 60 days or more at 65.5° C. without

decomposition. All other powders giving a shorter test are of course tested more frequently in the aforementioned Monthly, Bi-monthly, and Quarterly tests, inasmuch as they have a correspondingly greater tendency to decompose and must be more carefully watched.

Whenever any index gives loss of stability in the daily or fortnightly examinations (including violet paper test), it shall be immediately subjected to the surveillance test.

POWDER SHALL NOT BE DESTROYED UNLESS IT SHOWS UNMISTAKABLE SIGNS OF ADVANCED DECOMPOSITION. In the event of such deterioration every charge of the index on board shall be examined, and only such charges will be destroyed as contain the decomposing powder. Decomposition in the sense here used is evidenced by:

(*a*) **The grains being friable and easily crumbled.**
(*b*) **Unmistakable odor of nitrous fumes.**
(*c*) **Very low violet paper and surveillance tests.**

POWDER FOUND TO BE IN A SOFT OR MUSHY CONDITION SHALL BE THROWN OVERBOARD IMMEDIATELY. IT IS DANGEROUS. Whenever any powder is landed or destroyed because of its unstable or decomposed condition, samples of each index shall always be preserved and forwarded to the naval proving grounds for examination and the Bureau of Ordnance shall be notified at once of the shipment and the reasons therefor.

FIXED AMMUNITION

Propelling-powder charges for fixed ammunition shall be subjected to all of the foregoing tests in the same manner as separate ammunition, the projectile being removed from the cartridge-case for the purpose.

SMALL-ARM AMMUNITION

Small-arm ammunition for rifles and automatic pistols need not be tested.

GUN-COTTON

Examination and test of all dry gun-cotton on board ship shall be made weekly and monthly.

All wet gun-cotton shall be tested quarterly.

DRY GUN-COTTON — weekly test — all dry gun-cotton on board ship (dry gun-cotton primers) shall be examined weekly in the glass jar containers. The jar shall not be opened. Merely observe the condition of the gun-cotton blocks and the strips of blue litmus paper between them.

If any serious decomposition has taken place, **the gun-cotton will be found covered with pasty yellow spots; the jars will be filled with brownish red highly acid fumes, and the litmus paper will show a decided red color.**

Monthly test. — Even if no change is observed in the litmus paper at the weekly inspections, the following test is to be made once a month. Lift the block out of the jar by the loose ends of the tape, and place it on a clean, dry piece of blotting paper. Then untie the tape and separate the blocks, taking care not to touch them with the fingers. (A clean, dry, crash towel may be used for handling.) **Remove the strips of litmus paper, insert freshly moistened strips in their places, and return gun-cotton to jar. After an interval of one hour, examine the ends of the strips of litmus paper for a possible change of color from blue to red.**

WET GUN-COTTON — Quarterly test. — When wet gun-cotton is packed in torpedo war-heads or in mine charge cases, the weight of the wet gun-cotton and its container is stamped on the outside of the case. The gun-cotton, wet, contains 25% of its weight in water. Every three months every container of wet gun-cotton is weighed. If the gross weight is less than that stamped on the case or container, it is made up by the addition of pure distilled water through the filling hole, **which is then closed carefully.**

TNT (TRINITROTOLUOL)

TNT (Trinitrotoluol) is rapidly coming into more extensive use in the Naval Service as an explosive, replacing gun-cotton to some extent for torpedo war-heads, mine charges, etc.

Some of the most advantageous features of TNT are its chemical stability, its lack of sensitiveness to shock or impact, and the absence of fire risks.

From the above it is evident that no special precautions are necessary in the case of this explosive. Atmospheric changes or conditions have no effect on it. It may be stowed in any magazine or store-room.

OTHER EXPLOSIVES

Examination and tests of all other explosives used in the Naval Service shall be made as directed from time to time by the Bureau of Ordnance.

As a general rule no explosive other than those cited is carried in bulk on board ship.

CHAPTER XV

CARE AND HANDLING OF AMMUNITION

DETERIORATION BY EXCESSIVE HANDLING — PRECAUTIONS IN LOADING ON BOARD AND DISCHARGING — CARE IN STOWAGE

EXCESSIVE HANDLING. Ammunition shall be handled as little as possible. Excessive handling is often the cause of deforming powder tanks to the detriment of their air-tight condition.

Powder stored for a considerable period in a non air-tight container is inclined to deteriorate rapidly, introducing the danger of spontaneous combustion. Charges that are not in air-tight containers should be landed at the earliest opportunity for repairs, or replacement of the containers.

Too much care cannot be given to keeping powder in air-tight containers. Excessive handling, also, is likely to make dents in cartridge cases, and loosen projectiles of fixed ammunition. Cartridge bags for breech loading rifles are made of the most suitable material obtainable, and, when issued, have ample strength. However, the **sharp edges of powder grains will cut through the bags if the charges are handled too much.**

DURING ANY HANDLING OF AMMUNITION on **board ship, such as loading or unloading an ammunition barge or lighter alongside, the following precautions must be strictly observed:**

Fly the red powder flag at the foremast head, which signifies to all other vessels in the vicinity that you are handling ammunition.

Lead out fire hose ready to direct stream of water from fire main on any fire that might start up in the vicinity of the ammunition.

Have pressure on fire main.

See that smoking lamp is out and have decks patrolled to see that no smoking is done while ammunition is being handled or lighter containing it is alongside.

All naked lights about decks must be extinguished.

While handling, keep ammunition away from any high temperatures.

Never permit powder to be exposed to the direct rays of the sun. This regulation applies to all ammunition. If necessary to transport it in open boats or through exposed places, see that it is effectually shaded.

PRECAUTIONS IN USE

Service or battle ammunition is supplied to ships for use in battle only. It is not to be used for drill at the guns; for any instruction that requires opening of the tanks or charges; for testing hoists or for any other purpose except under express instructions from the Bureau of Ordnance. Service ammunition shall be kept separate and distinct from target ammunition and shall not be expended at target practice except under special instructions.

Target ammunition is special ammunition made up for use at target practice. It is called **blind,** inasmuch as the projectile has no bursting charge. This ammunition can be used for drill, at the direction of the commanding officer of the vessel.

During firing, no ammunition other than that immediately required shall be permitted to remain outside the magazines.

There shall not be exposed (removed from the tanks) at one time in any one magazine more than one charge for each gun supplied by that magazine and then only as necessary to supply the demand. Neither shall exposed sections be permitted to accumulate in the handling-rooms.

Never use force greater than can be applied by the hand alone in seating a loaded cartridge in a rapid fire gun.

Never ram projectiles in turret guns by interposing sections of a powder charge between the base of the projectile and the rammer.

Always have hose led out and pressure on fire main, when firing guns.

When loading a gun, see that the ignition, or red end of the powder charge, is at the breech.

Blind shells only shall be used for sub-caliber target practice.

CARE AND PRESERVATION IN STOWAGE

The air-tightness of powder charge containers or tanks shall be rigidly maintained on board ship. Inasmuch as "smokeless powder" is manufactured to contain in the finished grain a standard percentage of "residual volatiles," which is as low as practical considerations permit, exceptional care must be taken in stowage, so that under normal conditions the volatiles will not become appreciably reduced. Any marked loss of weight of a charge due to a return to the atmosphere of the "volatiles" originally contained, results in "ballistic changes" which concern the explosive force of the powder charge and the velocity of the projectile in leaving the gun.

The **temperature of magazines** in which powder is stored must be carefully watched and regulated. **Smokeless powder shall not be stored in any magazine where the temperature is habitually near 95° F. If the temperature reaches 90° F., artificial means for reducing it shall be adopted.**

The ideal temperature for magazines is 60° F., at which powder is practically stable. The average or normal temperature of magazines is between 70° F. and 80° F. **If smokeless powder is ever exposed to a temperature of 100° F., a special report covering all circumstances shall be made immediately to the Bureau of Ordnance, stating also the period of time of the exposure.**

Ventilation of magazines shall also be carefully regulated,

and it shall be endeavored to have **the air changed every eight minutes.**

At no time shall ammunition of any character be exposed to the direct rays of the sun or subject to other abnormal conditions of temperature.

Projectiles in the service outfit of the ship shall not be altered or disassembled on board ship without explicit instructions from the department. They shall be kept free from dust and the paint and lacquer shall be removed when necessary. The old paint shall be scraped off before repainting in order that dimensions shall not be increased. **Projectiles for separate ammunition, five- and six-inch guns, are issued with rope grommets or slings to protect their rotating bands.** These shall be removed only when preparing for firing, unless stowage space requires their removal before firing. Slings shall be removed before shells are sent up ammunition hoists, as they might jam in the hoists. They shall be returned to the naval magazine after removal.

Empty cartridge cases, boxes, and powder tanks shall be handled and stowed with care and turned in at the nearest naval magazine at the earliest opportunity. Cartridge cases must not be deformed by severe handling while still hot from firing, and as soon as practicable thereafter they shall be thoroughly washed with hot soap and water, carefully dried, and repacked in the boxes in which they were supplied. The cartridge cases at all times, before or after firing, should be kept free from salt, moisture, oil, or grease of any kind; and, from time to time, they should be examined, especially at the neck and mouth, for signs of corrosion. Empty cartridge cases, powder tanks, and cartridge boxes are reloaded and refilled at the naval magazines ashore.

Wet gun cotton contains 25 per centum by weight of distilled water and is stowed in special magazines. These magazines should never be allowed to attain a temperature as high as 100° F. The wet gun cotton must never be exposed to the direct rays of the sun. The 25 per cent of water must be maintained at all times.

Dry gun cotton is stowed above the water line, away from

vital parts of the ship. It is carried in small quantities (primers only) and is kept in small, tightly closed glass jars. The jars must not be stowed near each other, as the force of the explosion of one jar would communicate to the others. They must not be stowed in the vicinity of the galley or other fires and not too near the battery. The jars must never be exposed to the direct rays of the sun or to a temperature above 105° F.

Empty small-caliber, small arm cartridges shall be preserved, together with clips, packing boxes, etc., and turned in to the General Storekeeper at certain specified naval stations. As soon as practicable after firing, immediately if possible, empty cartridge cases shall be decapped and thrown into water; then cleaned, dried, and packed for shipment.

CHAPTER XVI

GUN SIGHTS AND MECHANISMS

PRINCIPLE OF GUN SIGHTS AND GUNNERY — RANGE AND DEFLECTION — TELESCOPE AND PERISCOPE SIGHTS — TURRET SIGHTS AND SIGHT-MOUNTS — BORE-SIGHTING

THERE are three preliminary terms or definitions that must be fixed firmly in the mind before going into even the most elementary principle of gun sights.

(1) The **axis of the bore of the gun**, which is the straight line passing through the center of the bore of the gun from its breech to its muzzle, or its longitudinal geometrical axis.

(2) The **axis of training of the gun**, which is the **axis of the gun's motion around the horizon, or in azimuth.** It is also the axis of motion of the carriage of the gun, the carriage being that part of the gun mount which gives to the gun its motion in azimuth.

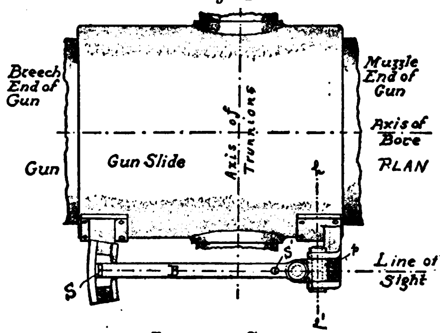
(3) **The axis of the trunnions**, which is the **axis of the gun's motion in elevation or up and down.** The trunnions are a part of the gun slide, projecting from it, one on each side. It is on the trunnions that the gun moves in elevation. The line passing through the center of the trunnions is the one with which we are at present concerned.

To bring about accurate shooting the axis of training and the axis of the trunnions must be perpendicular to each other at all times. This is effected by the accuracy of the gun construction and installation. If, then, the gun has been properly mounted on a ship's deck, the axis of training and the axis of the trunnions will be perpendicular to each other, and, when the ship is on an even keel and properly trimmed,

the axis of the bore, when the gun is moved in elevation, will move in a plane, which is perpendicular to the plane of the horizon.

LINE OF SIGHT. Theoretically, or in principle, the **line of sight** of any sight mechanism is **formed by mounting on a bar,** extending along the side of the gun or its mount and parallel to the axis of the gun, **two sight points called the front and rear sights and fixed in position relative to each other.**

Fig. 1



LINE OF SIGHT
TOP VIEW—LOOKING DOWN ON GUN

S, After sight point, V-notch; *S'*, forward sight point, cone; *h-h'*, Horizontal axis of sight mechanism; *p*, Pivot block; *B*, Pivot bar.

That end of the bar carrying the sight point which is nearest to the breech of the gun, is capable of a certain motion up and down in a vertical plane, **thus making it possible for a vertical angle to be formed between the line of sight and the axis of the gun bore. This vertical angle determines and regulates the range at which the gun is set to fire.**

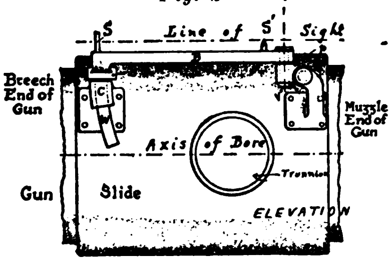
The same end of the bar, the end nearest the breech of the gun, is capable also of a certain motion, in suitable brackets, to the right and to the left in a horizontal plane, **thus making it possible for a horizontal angle to be formed between the line of sight and the axis of the gun bore.** This **horizontal angle determines and regulates the deflection at** which the gun is set to fire.

Therefore, summing up, we have theoretically, on every gun, a **line of sight that changes its angular position with relation to the gun bore, by means of the rear-sight point being moved up and down, and to the right and to the left.**

The gun bore itself, as we know, is capable of motion **in**

train, or to the right or left and **in elevation, or up and down,** the motion in train being given by the operation of the gun carriage, and in elevation by the operation of the gun slide, both of which are integral parts of the mount of the gun.

Fig. 2



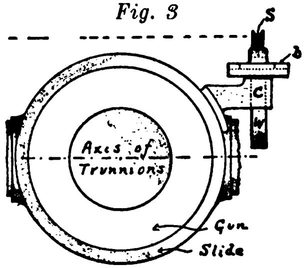
SIDE VIEW—LOOKING AT RIGHT SIDE

B, Pivot bar; *b*, Azimuth head; *W*, Sight bar; *C*, Sight bar bracket; *V–V′*, Vertical axis of sight mechanism.

The bar on which both the front and rear sight points are mounted is called the **pivot bar.** This pivot bar is mounted on the gun slide of the mount and so moves with the gun in elevation and in train but is not connected in any way to the gun itself, so is clear of it when the gun recoils after firing.

That end of the pivot bar that carries the forward sight point, or the end of the bar nearest to the muzzle of the gun, is pivoted to a bracket rigidly bolted to the gun slide. The **pivot carrying the forward end of the pivot bar is called the pivot block.** This pivot block is a small mechanical contrivance having two axes, perpendicular to each other. As the breech end or after end of the pivot bar is moved up and down and to the right and left, the muzzle end of the bar swings on these axes, using the horizontal axis when the line of sight is altered to accomplish range or elevation and the vertical axis for deflection.

Fig. 3



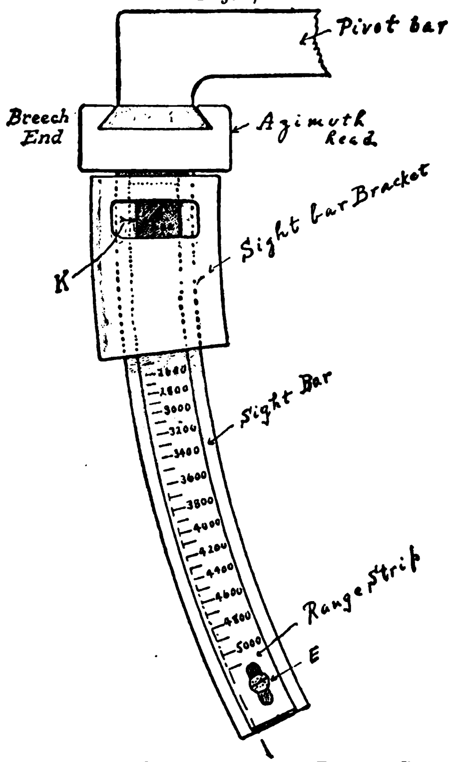
END VIEW—LOOKING AT BREECH OF GUN

W, Sight bar; *b*, Azimuth head; *C*, Sight bar bracket; *S*, Rear sight point.

That end of the pivot bar that carries the after or rear sight point, or the end of the bar nearest to the breech end of

the gun, carries a curved **sight bar**. This sight bar projects downward from the end of the pivot bar and is made in one piece or casting with it. The sight bar is in the form of an arc, the radius of which is the pivot bar and the center the pivot block or the horizontal axis of the pivot block. The sight bar operates or slides up and down in an accurately machined receptacle called a **sight-bar bracket** which permits of no lost motion of the sight bar in the bracket. The sight bar is fitted on its outer face with a white metal **range strip,** which is graduated, usually in 50-yard divisions from zero yards to 8,000 yards in the case of a 3-inch gun and from zero yards to 17,500 yards in the case of larger medium caliber guns, the range increasing, of course, with the caliber of the gun.

Fig. 4



Details of Sight Bar and Range Strip
K, Zero or reference mark on sight bar bracket; *E*, Elongated holes in range strip.

When the sight bar is set at zero yards range, there should be no vertical angle between the axis of the gun bore and the line of sight; that is, the axis of the gun bore and the line of sight will theoretically be parallel in horizontal planes.

Also at the rear or breech end of the pivot bar, in addition to the sight bar, there is a **pointer bolted fast to the side or end of the pivot and sight bars toward or facing the breech of the gun.** This pointer, which we will call an **azimuth pointer,** is carried by the end of the pivot bar and moves to the right and left as the breech end of the pivot bar moves to the right and left. The breech or rear end of the pivot bar has its motion to the right and left in an **azimuth head,** which is merely a bracket similar to the sight-bar bracket, except that it carries the breech end of the pivot bar and permits it to have a certain motion to the right and left in an arc of a circle the radius of which is the pivot bar and the center the vertical axis of the pivot block.

The **lower or pointer end of the azimuth pointer** rests on a slightly curved surface or plate, which is called the **azimuth plate,** the plate being bolted to the breech side of the **sight-bar bracket** and so being fixed in position with relation to the gun slide and other parts of the sight mechanism.

The **azimuth plate** is of white metal and its surface is divided into divisions representing corrections to be applied so that the line of sight will be set at the proper angle with the axis of the gun bore to compensate for any effect on the accuracy of firing that would be produced by a certain speed of the firing ship, of the target ship, for force of wind and other lateral errors of gun-fire.

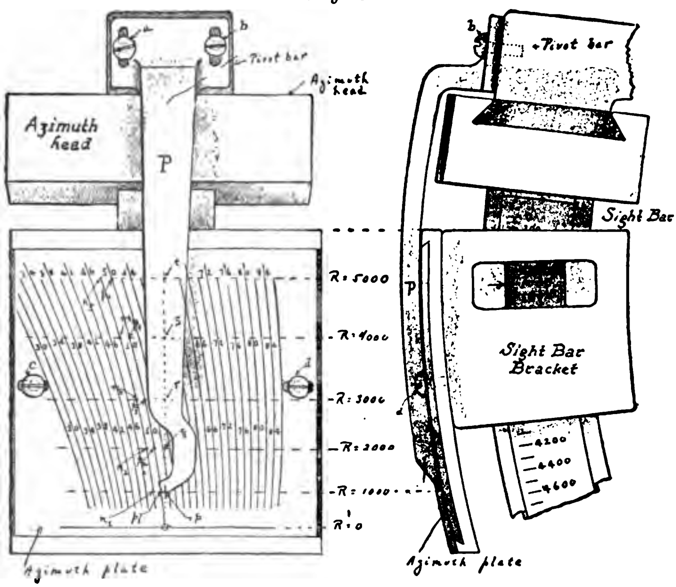
When the deflection is set at zero or at fifty, which, on any deflection scale, corresponds to zero for purposes of simplicity; that is, when the azimuth pointer rests on the fifty division of the azimuth plate, **then there should theoretically be no horizontal angle between the axis of the gun bore and the line of sight.** The axis of the gun bore and the line of sight will be parallel in vertical planes.

RANGE AND DEFLECTION SCALES

Every sight mechanism, as may have been inferred from what has gone before, is fitted with **two kinds of sight scales.** The first, the **range scale,** controls and indicates the line of

sight for the elevation or depression of the gun bore, the line of sight for this purpose being altered to form a predetermined vertical angle with the gun bore. The second, the **deflection scale,** controls and indicates the line of sight to compensate for various speeds of ship and target, for wind, drift

Fig. 5



DETAILS OF AZIMUTH PLATE AND SCALE

P, Azimuth pointer; *a–b*, Elongated holes in azimuth pointer; *c–d*, Elongated holes in azimuth plate.

of projectile, etc., the line of sight for this purpose being altered to form a predetermined horizontal angle with the gun bore.

RANGE SCALES of the direct-reading type are fitted to all sight mechanisms of the design that has just been described.

A **range strip of white metal** is dovetailed or set into the face of the sight bar, so that its face is flush with the face of the sight bar. The range strip is engraved with a mark or division and also a number at every point on the scale that represents a difference in range of 50 yards. The divisions

run from zero to 8,000 yards' range in the case of a 3-inch caliber gun, and in the case of guns of larger caliber, the range increases correspondingly with the caliber. The **sight-bar bracket**, through which the whole sight bar moves, **contains a reference mark or arrow-head.** When this arrow-head points directly across to the zero mark on the range strip, or when they are in coincidence, the line of sight is practically parallel to the axis of the bore. See Fig. 4, page 163.

In case the axis of the gun bore and the line of sight are aligned properly with relation to each other, as is the case when the gun is said to be **bore-sighted**, and the arrow on the sight-bar bracket is not in coincidence with the zero mark on the range strip, **the position of the range strip in the sight bar is changed by sliding the strip slightly up or down in its dovetail seat until the marks coincide.** There are elongated holes in each end of the range strip, which permit it to be shifted a very slight amount to take care of this adjustment.

Broadside guns are, as a general rule, capable of elevation through an arc of 15° and depression through an arc of 5°. These arcs are laid off on the range strip, using as a radius the length of the pivot bar from the sight bar to the horizontal axis of the pivot block.

In determining the amount of elevation of the gun necessary to accomplish a certain range, the gun is proof-fired at the Naval Proving Grounds. This proof-firing is conducted under standard conditions as follows:

(*a*) Atmosphere of unit density, given by a barometric height of 29.53 inches and a temperature of 59° F. The projectile will have a shorter range on a day when the atmosphere is below unit density or the air is heavier, and a greater range when the atmosphere is above normal density or the air is lighter, there being in the latter case less resistance to its path.

(*b*) A projectile of specified weight and form is used.

(*c*) Powder having a temperature of 90° F. and of an index that it is known will give a certain muzzle velocity in feet per second of the projectile as it leaves the gun.

(*d*) The wind on the range should be inappreciable, practically a calm.

Under these conditions the gun is fired at various elevations and the range strip is graduated in yards at the point or at the angle necessary to give this range in all subsequent firings. For example, if under standard conditions it was determined by proof-firing that an elevation of 5° 40′ on the sight bar was necessary to give a range of 5,000 yards, then an arc of 5° 40′ on the range strip is measured off from the zero division and marked 5,000 yards. 5,050 yards range will require a slightly greater arc and 4,950 yards range a slightly smaller arc and so on until a division is established on the range strip for every 50 yards.

MULTIPLYING TYPE RANGE SCALES are found in use on practically all modern guns. With high-power guns such as we have today, the range is so great that it is impracticable to have a pivot bar long enough to give a radius for the range-strip curve that will permit distinct spaces on the range strip for every 50 or 100 yard division. To obviate this difficulty, the **range scale or range strip is placed on a dial of brass, this dial being geared up from the sight bar.** The dial is fitted with a knob or handle, the operation of which raises or lowers the sight bar, by means of gears, in proportion to the revolution of the **range dial.** The divisions on the dial are well-separated from each other and are clear and distinct. **The dial is direct-reading from its face and the object attained amounts practically to a magnification of the range-strip divisions.**

DEFLECTION SCALES of the direct-reading type are well adapted to the explanation of the principle of these scales, although practically all guns now in use are fitted with **deflection scales of the multiplying type.**

An **azimuth plate** of white metal is, as has been said before, set into or dovetailed into the breech side of the sight-bar bracket, so that its face is flush with the face of the sight-bar bracket. This azimuth plate is capable of a certain slight movement to the right or left in its dovetail seat in the sight-bar bracket by virtue of the elongated holes in each end by means of which it is screwed down in position. **These elon-**

gated holes provide for the adjustment of the azimuth plate in bore-sighting the gun. See Fig. 5, page 165.

The **azimuth pointer,** attached to the breech end of the pivot bar and the pointer end of which indicates the divisions on the azimuth plate, is also made fast to the end of the pivot bar by elongated holes, which permit of its adjustment.

The **divisions on the azimuth plate consist of a series of curved lines,** equally distant from each other at the bottom of the plate, but gradually curving outward to the left and from each other as the top of the plate is approached. **The zero line is marked 50 for purposes of convenience and simplicity and is the center line on the plate. The numbers begin at the left-hand side of the plate below 50 and increase up to 50 at the center — then they increase toward the right of the plate beyond 50.**

Every division is numbered by twos, *i.e.*, 38, 40, 42, . . . from left to right. **Each division on the azimuth plate represents a speed of the target ship of two knots per hour.** This is an essentially important point and must be continually kept in mind — **the deflection scale is graduated in knots per hour for the speed of the target ship.**

The curved deflection lines are made necessary by the inclination of every projectile to **drift or travel in a path curving out to the right from a straight path by an amount increasing with the range at which the projectile is fired.** This drift is occasioned by the clockwise revolution of the projectile as it travels in its trajectory, the revolution being imparted to it by the rifling in the gun bore. The drift to the right increases with the range as the velocity of the projectile falls off as long ranges are approached.

The curved deflection lines on the scale take this drift into consideration and compensate for it automatically in setting the sights, so that in firing the gun no correction for drift need be considered.

The range and deflection scales are located with relation to each other, **so that when the range is set to zero on the range scale and the azimuth pointer rests on the 50 line at the bottom of the deflection scale, it rests also on a horizontal**

line across the face of the azimuth plate which corresponds to zero on the range scale. As has been stated before, for an increasing range, the deflection lines curve outward to the left, so that the range setting has an important bearing on the setting of the azimuth pointer. The sight mechanism is so constructed that the azimuth pointer moves up on the azimuth plate to a height corresponding to the range set on the range scale, the pointer being connected to the pivot bar at the same point as that from which the sight bar projects downward and so moves up and down with the sight bar.

The position of the pointer on the deflection scale being set automatically at a height corresponding to the proper range when the sights are set for range, all that remains to be done in setting the sights is to move the pointer to the right or left on the deflection scale at this height and to rest the end of the pointer on the proper or desired division, which is numbered at both top and bottom of the azimuth plate for guidance.

This sets the pivot-bar and the line of sight at the desired angle with the axis of the gunbore, both vertically and horizontally.

MULTIPLYING DEFLECTION SCALES are used on all modern high-powered guns. For deflection scales, the system is essentially the same as that described for multiplying range scales. In the case of deflection scales, an **azimuth drum** is provided, being in the shape of a small cylinder, mounted vertically in the sight mechanism. This drum has cut into its surface the deflection lines found on the azimuth plate, only on the drum the lines are better spaced, amounting practically to a magnification of the lines on the plate. In setting the sights for deflection the azimuth drum revolves on its vertical axis operated by a small knob or handle. The revolution of the drum actuates, by means of suitable gears, the motion of the breech end of the pivot bar to the right or left.

An **ARBITRARY DEFLECTION SCALE** is a new type of scale which has recently come into use in the service, but which is mounted on all guns now issued for use.

Its main point of difference from what we will call the

knot scale, which is the one previously described, is that it is not based on the speed of the target ship in knots per hour, nor does it make any allowance or compensation for the drift of the projectile to the right. It is based rather on an arbitrary scheme that one division on the deflection scale compensates or corrects one yard of deviation of the projectile from the target at one thousand yards range, two yards at two thousand yards range, three at three thousand and so on, one division on the deflection scale correcting one yard additional for every additional thousand yards range. The theory is that of a triangle having its apex at the gun and the base widening out one yard deflection for every thousand yards range. Therefore, say at one thousand yards range, two divisions on the scale would correct a deviation at the target of two yards, four yards at two thousand, eight at four thousand, etc.

As stated, this deflection scale does not compensate for drift of the projectile, so the deflection lines on the azimuth drum are straight diverging lines, rather than curved diverging lines. The divisions are numbered similarly to those on the knot scale.

The advantage of this type of a deflection scale is that it aids the fire-control spotter in judging deflection. They can think in yards rather than knots, and yards in the case of the arbitrary scale means divisions on the deflection or azimuth drum, without conversion.

In setting the sights of a gun, the member of the gun's crew termed the sight-setter is responsible for the proper setting of both range and deflection. The sight-setter has no other duties.

When the range and deflection scales are both set at zero, the line of sight of the gun is properly aligned with the axis of the gun bore, assuming of course that the gun is properly bore-sighted.

To fire the gun at a target distant 3,000 yards and make a hit the range scale is set at 3,000 yards (assuming no corrections for density, powder temperature, etc.). The breech end of the pivot bar is moved upward, elevating the rear-sight

point. Looking down the line of sight now, without elevating the gun, you look down into the water or the line of sight has been depressed. To bring your gun to bear on the target, you must now elevate the gun until the line of sight prolonged intersects with the target. If the gun is fired now, the projectile will curve upward at first, following in the path of its trajectory, and fall at the target.

To compensate the sights so that the gun when fired will hit the target after allowing for various **lateral errors of gunfire**, the following procedure is carried out. Previous calculations show that the projectile will fall to the left of the target by a number of yards corresponding to the length of a two-knot division on the deflection scale. **If the projectile falls to the left of the target by a certain distance, the sights must be so set that they will cause the projectile to fall that same distance to the right** of the previous point of fall on the second shot.

Always remember that the divisions on a deflection scale increase toward the right or clockwise, the 50 division being at the center.

Now, to alter our line of sight so that our projectile will fall to the right a distance equal to one division on the knot scale, change the sight or scale to the right, that is, set the scale at 50+2 or 52. **Always remember to move your deflection scale, increasing to the right, decreasing to the left, and in the same direction as that towards which you wish to bring the fall of your projectile.**

Setting the scale at 52 brings the breech end of the pivot bar toward the right, so that the line of sight prolonged inclines toward the axis of the bore and toward the left. The gun is now trained toward the right until the line of sight prolonged intersects with the target.

TELESCOPE AND PERISCOPE SIGHTS AND SIGHT-MOUNTS FOR MODERN BROADSIDE GUNS

The type of sight that has been described at length is the simplest one that we have. In this type it was assumed in

the description that the forward sight point was the apex of a cone and the rear or breech end sight point was the bottom of a V-shaped notch. In sighting, the apex of the cone was brought in line with the bottom of the V-notch and these two with the target formed the line of sight.

The **peep-sight** represents a still later type, but there are few even of these in practical use, except as auxiliaries for use in case of breakdown of other sight mechanisms. It differs from the **V-sight or open sight**, as it is called, only in one point; the rear or breech-end sight point consists of a disk having in its center a small "peep" hole. In sighting, the apex of the cone of the forward-sight point is brought in line with the peep hole of the rear-sight point and the line of sight thus established.

The **TELESCOPE SIGHT is practically the only one used in the Service at the present time on anything above guns of minor calibers.**

The telescope is mounted, or attached to the gun, in such a manner that the line of sight may be set at any desired angle with the axis of the gun. **In reconciling the idea of the telescope in the mind, try to picture it as the pivot bar of the sight mechanism that has been described, picturing the lenses and the cross-wires of the telescope, which determine its line of sight, as taking the place of the front and rear sight points of the other mechanism.**

Every modern broadside gun is fitted with two telescopes, **one for the gun pointer**, called the pointer's telescope, and the other **for the gun trainer**, called the trainer's telescope. The pointer's telescope is the one which provides principally for the elevation of the gun. The trainer's telescope provides principally for the training of the gun.

The trainer's telescope is always in modern practice located on the right side of the gun. The pointer's telescope is always at the left side of the gun.

Every telescope has fixed at its front end, corresponding to the front sight point of an open or peep sight, **cross-wires** that are either fixed at right angles to each other by being soldered in the end of the telescope, inside the lens, or are

represented by fine, straight lines etched at right angles to each other across the inside face of the lens itself. Etched lines are modern practice. The forward or front lens of the telescope is fixed in position, so that what we will call the vertical wire is always parallel to the axis of training of the gun. The horizontal wire is also so placed that it is always perpendicular to the axis of training and parallel to the axis of the trunnions. Both cross-wires are then rigidly fixed in their position with relation to each other and in planes with reference to the axes of motion of the gun.

In pointing or aiming the gun, the gun pointer is the man responsible. His firing key is located in the handle of his elevating-wheel, and, when both of the cross-wires are on, it is fair to presume that if the gun is fired, a hit will be made. **The gun pointer is at the elevating-wheel. Primarily he operates this wheel to bring the horizontal cross-wires of his telescope on the target. The gun trainer at the training wheel at the right side of the gun endeavors by this wheel to bring the vertical wire of his telescope on.** Of course, if each man has his wire properly on, then both wires of both telescopes will be on. The pointer must be satisfied as to the position of his own (the horizontal wire) and also as to the position of the trainer's vertical wire. If not satisfied on this point, he coaches the trainer by singing out "Train right a little" or "Train left" until the position of both wires is correct and to his satisfaction.

YOKE SIGHT-MOUNTS were, until recently, very extensively in use to fix the position of the telescopes with reference to the gun, these sight-mounts carrying telescope collars in which the telescopes were fastened by nuts or clamps.

The mount consists of a casting in the form of a yoke which is bolted to the slide of the gun mount, and which extends across the top of the slide at its breech end. At each side or extremity the yoke carries a collar for receiving the telescopes. **The whole yoke is capable of revolution on a vertical axis that is parallel to the axis of training of the gun and is located on the longitudinal center line of the gun or in the same vertical plane as the axis of the gun bore.**

The whole yoke is also capable of revolution about a horizontal axis which is parallel to the axis of the trunnions of the gun.

Referring back to the simple sight mechanism first described, it is seen that the **yoke sight-mount follows identically the same principles.** The only difference is that the **yoke gives a line of sight on each side of the gun.**

The yoke sight mount is connected up to the range and deflection scales similarly to the simple sight mechanism.

PERISCOPE SIGHTS for broadside guns are the very latest type of sight mount and sight combined. With the ordinary type of yoke mount the wide distance between the two telescopes at the top of the gun slide makes necessary a large opening in the gun shield to permit the lines of sight to pass out between the gun and the edge of the port or shield opening. The periscope sights act on the same principle as any periscope. **The line of sight is deflected at the end of the telescope by a prism which turns the line of sight down through an angle of 90°. Under the gun and close in to the circumference of the slide, the line of sight is again deflected through another angle of 90°, this time outward, being directed at the opening in the port-shield under the gun.** These telescopes are also called **prism** telescopes, due to the fact that the prisms twice deflect the line of sight through right angles.

Periscope sights are mounted on yoke mounts similar in principle to the one described for ordinary telescope sights.

The periscope sights make possible a very small opening in the gun shield, the line of sight going out close to the gun itself. It also permits a wider training arc of the gun, as the sights will not so soon be masked by ship parts when the gun is trained to extreme right or left.

The **sighting telescopes** in use in the service are all practically of the same type.

All are what is known as **variable power telescopes**; that is, the variable power is obtained by moving the eye-piece

tube in or out and then clamping it at the desired power or magnification. The telescope is then focused.

The **prismatic or periscopic telescope** has been described and deflects the line of sight through two right angles.

A CHECK TELESCOPE is one used for checking purposes. It is usually in the form of a second eye-piece projecting out from the side of both the pointer's and trainer's telescopes at right angles. Its purpose and use is in the training of gun pointers and trainers. Two eye-pieces on one telescope of course divide the light in half, so when the checking eye-piece is not in use, it is covered.

TURRET SIGHTS AND SIGHT-MOUNTS

The principles of gun sights and mechanisms that have been described apply equally to turret guns as to others.

In ships of the pre-dreadnought type most of the two-gun turrets have in the roofs of the turrets small, cylindrical projecting hoods called **sight hoods.** In front of each of these sight hoods is an opening through which the line of sight goes out. These hoods are necessary because the gun port or opening in the front of the turret through which the gun projects must only be big enough to permit the elevation of the gun. An opening bigger than this would be dangerous.

The sight mechanism of turret guns differs radically from that of other guns in this following particular. **The two guns of a turret are elevated individually, but are trained together by the revolution of the whole turret.** Each gun in the turret is therefore equipped with a range scale and mechanism for altering the direction of the line of sight to accomplish a change in range. **Only one deflection scale is, however, provided to a turret,** and the sight mechanism governing deflection is located in a booth in the center of the turret between the two guns.

A gun pointer is necessary for each turret gun, but only one gun trainer is furnished to a turret.

Parallel motion sight-mounts are fitted to turret guns of older types, this sight-mount utilizing connecting rods, hav-

ing a parallel motion with respect to each other, but being fixed in their position with relation to the gun slide and trunnions. This mechanism, by virtue of the parallel motion, transfers the line of sight up to the high level of the sight hoods, while preserving the position of the line of sight relatively.

Periscope sights for turret guns are the only ones now used on modern ships. The telescope is of the same type as that described for broadside guns, the line of sight being deflected through two right angles. **Each gun has a pointer's telescope which is attached to the gun mount by suitable mechanism. The line of sight projects out through a hole in the side of the turret in a line with the axis of the trunnions of the gun, the telescope projecting out parallel from the side of each gun.**

Each turret has a trainer's telescope which is located in the center of the turret between the two guns. This telescope is mounted vertically and the line of sight from it projects out through an opening in the front of the turret between the two guns.

On the **new three-gun turrets** installed on the latest superdreadnoughts, the guns are all trained and elevated together and only one sight mechanism with one range and deflection scale is used.

BORE-SIGHTING

BORE-SIGHTING a gun is the procedure of aligning the lines of sight with relation to the axis of the gun bore so that they will intersect each other, prolonged, at the mean battle range of the gun, say at 5,000 yards, for a medium-caliber broadside gun.

If the line of sight of any gun could be coincident with the axis of the bore of that gun, an important error of gun-fire would be eliminated. It is necessary, however, to mount the sight brackets and the sight mechanism on the gun slide of the mount, which is the best available place for it, so as to give a clear line of sight while firing and also to keep the sights

away from the mechanism of the gun. This brings the line of sight, although essentially parallel in vertical and horizontal planes to the axis of the gun bore, **to the left and above the gun bore.**

If the range of our gun were infinite or without limit and the line of sight parallel to the axis of the bore, while to the left and above it, whatever the range or the distance of the target from the gun, the projectile would hit the target at a point to the right and below that aimed at by the same distance that the line of sight was to the left and above the bore of the gun, **or miss it by that same distance.**

In modern battle practice every caliber gun has a certain **mean battle range** which is the most effective range for that gun, and the range at which it will open fire on an enemy vessel if possible.

To overcome the error referred to above and which is due to the distance between the line of sight and the axis of the bore, the procedure of **bore-sighting** is resorted to.

Assuming that the gun to be bore-sighted has a mean battle range of 5,000 yards, we proceed to set the lines of sight at such an angle with the axis of the bore of the gun that they intersect at the objective or target at this mean range of 5,000 yards, **while the range and deflection scales are each set at zero.**

Now, if the gun is fired while pointed at a target at 5,000 yards distance or range, a hit will be registered. If, however, we shoot at 2,500 yards range, while bore-sighted at 5,000 yards, we will hit the target $2\frac{1}{2}$ feet low. At 7,500 yards range we will hit the target $2\frac{1}{2}$ feet high, assuming in each of these cases that there is a difference of five feet between the line of sight and the axis of the bore. The error in shooting at a range other than that at which bore-sighted is, as can be seen, comparatively small, and, in any event, it is less than if the gun were not bore-sighted at all, in which case you would have a constant error of five feet, assuming this distance between bore and line of sight.

THE PROCEDURE IN DETAIL TO BE FOLLOWED IN BORE-SIGHTING A GUN AT ITS MEAN BATTLE

RANGE, SAY 5,000 YARDS, IS AS FOLLOWS: (1) Anchor a small boat out at the desired distance, 5,000 yards in this case. Mount on it a regulation target screen. If impossible to anchor out a small boat, select a prominent object off-shore at the desired range.

(2) **Open the breech-plug of the gun and lash it open,** so that there is no danger of its swinging to and injuring the bore-sighting gear. This is mandatory.

(3) **Ship the breech-disk in the screw box of the gun,** and clamp it rigidly in position.

(4) Enter the **breech-disk telescope** in the threaded hole in the center of the breech-disk, screwing it home. There are three clamp-screws in the breech-disk that set up on the telescope. Set up on them gradually in succession, so that the telescope will be in line with the axis of the bore as nearly as possible.

(5) **Focus the breech-disk telescope** for distinct vision on an object distant about one mile, by adjusting the eye-piece.

(6) **Ship the muzzle disk in the muzzle of the gun,** sending a man out astride the gun for the purpose of seating it. See that the lip on its circumference touches the face of the muzzle all around.

(7) By manipulating the set or clamp screws about the telescope in the breech-disk, **adjust the line of sight of the telescope so that it passes through the center of the hole in the muzzle disk.** The hole in the muzzle disk, which is about $\frac{1}{16}$ of an inch in diameter, will appear to the observer as an indistinct, bright spot. The other holes around the center hole in the muzzle disk are for the admission of light. **When the cross-wires of the breech-disk telescope are centered on the hole in the center of the muzzle disk, the telescope is exactly in line with the axis of the gun bore.**

(8) Test the adjustment of the bore-sight telescope by rotating the muzzle disk through 180°.

(9) Remove muzzle disk.

(10) **Set range and deflection scales at zero.**

(11) With an officer, if possible, at each telescope; **pointer's,**

trainer's, and bore-sight telescope, and chief petty officers, if commissioned officers are not available, direct the line of vision at the target.

Adjust first the horizontal wires of both telescopes (trainer's and pointer's); then the vertical wires. Taking, for example, the adjustment of the horizontal wires, the man at the breech coaches in elevation and train until his horizontal wire rests on the target, when he sings out, "Mark!" "Mark!" and keeps on singing out as long as the horizontal wire of his telescope is in that position. The man at the elevating or pointer's telescope notes how much his horizontal wire is off and by moving the sight bar he brings the wire on to coincide with that of the breech telescope. The man at the training telescope follows the same procedure, adjusting his telescope when the man at the elevating telescope has completed his adjustment, but effecting it by shifting his (the trainer's) telescope slightly in the telescope collar, by means of a small screw, raising or lowering until the horizontal cross-wire is on.

The vertical wires are adjusted by practically the same procedure. The trainer's vertical wire is adjusted first, in this case, by altering the setting of the sights in azimuth on the deflection drum until the vertical wire on the trainer's and the breech-disk telescope coincide on the target. The vertical wire of the pointer's telescope is now adjusted slightly if necessary to agree with the other two by shifting the telescope in its collar by means of the tangent screw.

The positions of the azimuth plate and range strip are now shifted slightly to bring the 50 division on the azimuth plate under the azimuth pointer or indicator and the zero division of the range strip opposite the reference mark of the sight-bar bracket. The shifting of both scales is effected by moving the azimuth plate and range strip slightly by means of the elongated holes by which they are held in position.

(12) Replace the muzzle disk and check with bore-sight telescope to make certain that the telescope in the breech-disk has not moved slightly during the bore-sighting.

(13) Remove breech and muzzle disks. Hang sign on gun, **Bore-sighted, Hands Off!** This keeps thoughtless persons from tampering with the gun.

After firing a gun, bore-sight as soon as possible to check up any derangement of the sights.

When bore-sighting on a battleship, or any other vessel for that matter, all guns of a battery that will fire together, or in salvo, during an action, should be bore-sighted at the same time, under the same conditions of weather, and at same time of day.

Division Officers are responsible for the proper bore-sighting of their guns. It is customary after bore-sighting a gun and before removing the bore-sight apparatus to have the gun's regular pointer and trainer " check up " and state that they are satisfied that the gun is properly bore-sighted. This makes impossible a later complaint that poor bore-sighting might have been responsible for a poor string of shots at a target practice or in an engagement.

In turret gun bore-sighting, the axes of the two guns are supposed to be made parallel or to converge slightly. If bore-sighting at a long range, the position of the trainer's line of sight should be midway between the pointer's lines of sight when all scales read zero; this, of course, puts both pointers a little bit off laterally when the trainer is on. Firing at a short range where this discrepancy will amount to a considerable portion of the target, the trainer should lay his line of sight a little to the right of the bull's eye when the left gun is to fire and vice versa for the right gun, the amount from the bull's eye being one half the divergence between the two pointers' lines of sight.

Chapter XVII

ELEMENTARY NAVAL GUNNERY

FUNDAMENTAL DEFINITIONS AND PRINCIPLES — ERRORS OF GUN-FIRE — ELEMENTS AFFECTING INITIAL RANGE AND DEFLECTION — RANGE TABLES

BALLISTICS is the term applied to and the science treating of the motion of projectiles fired from a gun.

Interior ballistics concerns the motion of the projectile inside the gun, or while it is traveling down the gun bore.

Exterior ballistics concerns the motion of the projectile while traveling in the air, or between the time it leaves the gun muzzle and its point of fall or impact.

The trajectory of a projectile is its path in the air from the muzzle of the gun to its point of fall or impact. This path or trajectory is in the form of a long curve, more or less pronounced, depending upon the degree of elevation of the gun muzzle; the greater the elevation, the more curved the trajectory.

A trajectory curves in two directions: gradually downward and then more abruptly, as the projectile nears the culmination of its range; and to the right; this statement does not, of course, consider the first curve of the projectile upward as it leaves the muzzle, due to the elevation of the gun. The downward curvature is caused by the force of gravity. The curvature to the right is caused by the rotation of the projectile about its axis: **drift.**

The **range of a projectile** is the actual linear distance (the shortest line) from the gun to the point of fall or the inter-

section of the trajectory with the pointer's line of sight, prolonged.

The **angle of elevation of a gun** is the vertical angle between the axis of the gun bore and the line of sight as set to accomplish a certain range of projectile. To fire at a certain range, you set your sights for that range, depressing the line of sight. To bring the line of sight on the target, you elevate your gun muzzle. Now your muzzle has been elevated through a certain vertical angle, while the line of sight is essentially in a horizontal plane. The degree of the elevation of the gun muzzle over the line of sight is the angle of elevation.

Jump is a small vertical angle described by the muzzle of a gun when it is fired. Under the shock of discharge, the gun muzzle jumps slightly upward from its angle of elevation each time it is fired, due to a certain yielding of the supports of the gun. This angle of jump is so small that under ordinary circumstances it is considered negligible and is discarded. It must be looked for, however, as in certain cases it develops excessively, due to loose or faulty setting-up of the gun mount, and if not compensated for, will introduce a large error of gun-fire.

The angle of position is the small vertical angle formed at the target by the distance, at the gun, between the water's edge and the line of sight. It is due to the elevation of the gun and line of sight above the surface of the water. Under all normal circumstances it is considered negligible and is discarded.

The **line of departure** of a projectile is the line on which it actually leaves the gun muzzle. It would be represented by a line drawn tangent to the trajectory at the muzzle of the gun.

The **angle of departure** is theoretically the vertical angle at the gun between the surface of the water and the actual line of departure of the projectile. As such it includes the angle of jump, the angle of elevation, and the angle of position. **Practically, the angle of jump and of position can be considered to be negligible, so that, for naval gunnery, the angle**

of departure and the angle of elevation can be assumed to be one and the same.

The angle of fall of the projectile is the vertical angle, at the point of fall or impact of the projectile, between the plane of the horizon (or the surface of the water) and a line drawn tangent to the trajectory at the point of fall.

The angle of fall or impact of any projectile, in order that it be properly effective, should never be greater than 10 degrees from the horizontal. An angle greater than 10 degrees strikes a glancing glow, particularly on armor plate, accompanied by a lack of penetration.

The **DANGER SPACE of a target, ship, or any objective is the area of water behind it within which the projectile would fall if it passed through any part of the target. That is, if the projectile falls in this danger space or area of water, to do so, it must have first passed through at some point of the target.**

In connection with the discussion of a danger space, it is timely to mention the **advantages of a flat trajectory. The flatter the trajectory, the greater will be the danger space, which, of course, is one of the main things we are striving for.** The flatter the trajectory, the less chance there is of missing our target vertically. **Modern naval guns are all what we call "high-power guns,"** meaning that they are designed to withstand high powder pressures and to impart a high muzzle or initial velocity to the projectile; high muzzle velocities giving flat trajectories. Modern muzzle velocities range usually in the vicinity of 2000 to 2900 feet per second.

Having covered the preliminary terms, a knowledge of which is essential to a proper and thorough understanding of the subject, we will proceed to a discussion of the underlying principles of gunnery.

The term "GUNNERY" refers to the use of the guns of a ship. The aim of all naval gunnery is to score the greatest possible number of hits on an enemy ship, or on a target, in the shortest possible time and under various and changing conditions. It is also of prime importance that the enemy

ship be hit as early in the engagement as possible. **Too much emphasis cannot be laid on the necessity of securing the initial advantage, or of hitting the enemy before he hits you.** A well-directed broadside hitting the enemy at the beginning of an engagement, and before he gets your range, will not only disable, but demoralize him, and the battle is already partly won.

To bring about rapid and accurate shooting of this character, we must not only have well-drilled gun crews and pointers, but we must have in addition, **an efficient system of fire-control and a method of calculating the range and deflection at which we will set our sight scales for the first or initial shot or salvo of shots in opening fire.** The accuracy of these calculations may cause our first shots to fall on or near the enemy and so give us the much-desired " initial advantage."

When an enemy vessel is first sighted, the range-finder is used to determine his distance from your own ship. His bearing by compass is also taken, simultaneously, and the time noted by stop watch. At short, designated intervals of time thereafter, usually every thirty seconds, another simultaneous range-finder reading and bearing of the enemy vessel are taken. After several minutes, enough observations have been taken to lay off on a chart a series of spots or fixes, each representing the position of the enemy with reference to your own ship at a certain instant. **A line drawn through these spots represents, fairly accurately, the course and speed of the enemy and his distance.**

The captain of your ship will choose the time at which he will open fire on the enemy, giving due consideration to all conditions. He also will advise the gunnery officer in advance of his intentions in this regard. **The instructions for opening fire will usually be in this form : Open fire when the enemy is bearing North-East (for example) and is distant 9000 yards (for example) by range-finder, using 12-inch battery.**

The gunnery officer must now figure out or determine, and quickly, what the setting of the sights in range and deflection must be to cause the first shot or salvo of shots to fall on or near the enemy.

The range-finder operators have continued, ever since the enemy was sighted, to take, at short, periodic intervals, the range and bearing of the enemy, and the plotting of these observations on our chart enables us to note quickly any change in his course or speed.

If both our firing ship and the enemy ship were anchored, or even traveling on parallel courses at the same rate of speed; **if there was a calm** or no appreciable wind; **if the moisture in the atmosphere and the temperature were both normal,** giving us a normal density of atmosphere; **if our powder was of even quality and temperature** and could be depended upon to give a standard muzzle velocity of projectile; **if the ship's guns were new** and could be depended upon to give a range of projectile exactly as set on the range scale; **and if, also, our projectile would travel straight forward in its trajectory** instead of curving off to the right, due to the drift occasioned by its rotation; **then, the distance found by means of our range-finder could be set directly on our range scale — we would have little or no deflection — and we could be assured of a hit, assuming accurate gun pointing.**

HOWEVER, NONE OF THESE IDEAL CONDITIONS EXIST and we must make accurate computations to determine the amount or the number of yards that we must set on our range scale, above or below 9000 yards, **which was the actual distance the enemy ship was from us at the moment the firing keys of our guns were pressed,** in order to make a hit, considering that both ships are moving at different speeds, and either in the same or in different directions; also considering the effect of various other **errors of gun-fire.** The determination of the change in the deflection setting to the right or left of the 50 division must also be determined for its errors of gun-fire and for the motion of ship and target. **This we call the determination of initial range and deflection.**

Initial range and deflection is the exact setting to be placed on the range and deflection scales of our sight mechanisms in order to align the guns' lines of sight for firing the first shot or shots at the enemy.

RANGE TABLES

Every gun of a certain size and type issued to the Service (especially as regards the diameter of the gun bore, or its caliber, and also the length of the gun bore, in calibers) is designed and produced to carry a uniform charge of powder, **and to eject a projectile of standard weight and shape out of the gun muzzle at an initial velocity in feet per second that will be uniform for all guns of that particular size and type.**

RANGE TABLES are issued by the Bureau of Ordnance of the Navy Department, — one for every different size and type of gun. These tables contain computed data at various ranges (usually for every sight-bar setting of 50 or 100 yards) that enable us to obtain corrections to be applied to the observed range and deflection, for such conditions that affect them, and that are other than normal at the moment of firing. Also they contain data enabling us to make the necessary corrections to allow properly for the speed and course of both firing and target ships, and in addition, other data aiding generally in the accurate control of fire.

Each range table has printed on its outside cover, in large type, the particular size and type of gun for which it is computed, viz.:

3-inch, 50 Cal., i. v.–2700 ft. / sec.
6-inch, 50 Cal., Mark VIII, i. v.–2800 ft. / sec.
14-inch, 45 Cal., Mark I, i. v.–2600 ft. / sec.

ERRORS OF GUN-FIRE

RANGE of a projectile is the actual linear distance in yards (the shortest line) from the gun muzzle to the point of fall of the projectile in the water. It may also be defined as the linear distance from the gun to the intersection of the trajectory of the projectile with the pointer's line of sight, prolonged.

DEFLECTION of a projectile is the actual linear distance in yards that it falls to the right or left of a target or objective at which the line of sight of the gun is directed, due to

EXTRACT FROM RANGE TABLE FOR 3-INCH GUN

Weight of projectile for which this table is calculated, 13 pounds. Initial velocity, 2,700 foot-seconds.

Range	Angle of departure = angle of elevation plus jump		Angle of fall		Time of flight	Striking velocity	Drift	Danger space for a target 20 feet high	Maximum ordinate	Penetration of Harveyized armor with capped projectiles	Change of range for variation of ± 50 foot-seconds, initial velocity
1	2		3		4	5	6	7	8	9	10
Yards	°	′	°	′	*Seconds*	*Foot-seconds*	*Yards*	*Yards*	*Feet*	*Inches*	*Yards*
3000	2	02.4	3	26	5.05	1230	3.4	114	104	1.5	68
3100	2	09.4	3	42	5.30	1203	3.8	106	115	1.5	69
3200	2	16.7	3	58	5.55	1178	4.2	98	126	1.4	70
3300	2	24.3	4	15	5.81	1154	4.7	91	138	1.4	71
3400	2	32.2	4	32	6.07	1132	5.2	85	151	1.3	72
3500	2	40.4	4	50	6.33	1112	5.7	80	165	1.3	73
3600	2	48.9	5	08	6.60	1094	6.3	75	180	1.3	74
3700	2	57.6	5	27	6.88	1077	6.9	71	196	1.3	75
3800	3	06.6	5	47	7.16	1061	7.6	67	213	1.2	76
3900	3	15.9	6	08	7.45	1046	8.3	63	231	1.2	77
4000	3	25.5	6	30	7.74	1031	9.0	59	251	1.2	78
4100	3	35.4	6	52	8.03	1017	9.8	56	272	1.2	79
4200	3	45.6	7	14	8.33	1004	10.7	53	294	1.2	80
4300	3	56.1	7	37	8.63	992	11.6	50	317	1.1	80
4400	4	06.9	8	00	8.94	981	12.6	48	341	1.1	81
4500	4	17.9	8	24	9.25	971	13.7	46	366	1.1	82

EXTRACT FROM RANGE TABLE FOR 3-INCH GUN

Weight of projectile for which this table is calculated, 13 pounds. Initial velocity, 2,700 foot-seconds.

Change of range for variation of ± pounds in weight of projectile	Change of range for variation of density of air of ± 10 per cent	Change of range for wind component in plane of fire of 12 knots	Change of range for motion of gun in plane of fire of 12 knots	Change of range for motion of target in plane of fire of 12 knots	Deviation for lateral wind component of 12 knots	Deviation for lateral motion of gun perpendicular to line of fire, speed of 12 knots	Deviation for lateral motion of target perpendicular to line of fire, speed of 12 knots	Change in height of impact for variation of ± 100 yards in sight bar	
11	12	13	14	15	16	17	18	19	20
Yards	*Yards*	*Yards*	*Yards*	*Yards*	*Yards*	*Yards*	*Yards*	*Feet*	
—	122	18.5	15.6	34.1	11.6	22.5	34.1	18	—
—	129	19.8	16.0	35.8	12.5	23.3	35.8	19	—
—	136	21.1	16.4	37.5	13.4	24.0	37.5	21	—
—	143	22.5	16.7	39.2	14.4	24.8	39.2	22	—
—	150	23.9	17.1	41.0	15.4	25.5	41.0	24	—
—	157	25.3	17.5	42.8	16.5	26.3	42.8	25	—
—	164	26.8	17.9	44.7	17.6	27.1	44.7	26	—
—	171	28.3	18.2	46.6	18.7	27.8	46.6	28	—
—	178	29.8	18.6	48.5	19.8	28.6	48.5	30	—
—	184	31.4	18.9	50.4	21.0	29.3	50.4	32	—
—	190	33.0	19.3	52.3	22.2	30.1	52.3	34	—
—	196	34.7	19.6	54.3	23.4	30.8	54.3	36	—
—	202	36.4	20.0	56.3	24.7	31.6	56.3	38	—
—	208	38.1	20.3	58.3	26.0	32.3	58.3	40	—
—	214	39.8	20.7	60.4	27.3	33.1	60.4	42	—
—	220	41.5	21.0	62.5	28.6	33.8	62.5	44	—

certain errors of gun-fire and to changes caused by the varying (with relation to each other) courses and speeds of the firing and target ships.

PRINCIPAL ERRORS OF "RANGE"

DENSITY OF THE ATMOSPHERE. It can readily be understood that a projectile, especially at long ranges, will go considerably farther, or **have a greater range, when the density of the atmosphere is less than normal or when the air is more light or rare.** In this case there is less resistance to the projectile in its trajectory. **Similarly, a projectile will not go as far if it has to travel through a more dense medium or atmosphere**; its range will be shorter as there is more resistance to its path.

Normal density is unity and is based on a temperature of the outside air of 59° F. and a barometric height of 29.53 inches; this is the standard temperature of half-saturated air.

To correct our range-finder range for the error caused by a density of the atmosphere other than unity at the moment of firing, we first find from our thermometer and barometer readings, by entering with them in "**ALGER'S BALLISTIC TABLES**" (Table III) the corresponding density based on unity. Let us assume this density at (0.95). Unit density is (1.00). The difference is (0.05) or 5%. **Our atmosphere, then, is 5% less dense or more rare than normal and our projectile will travel farther than it would under normal conditions.**

The change in the range of the projectile, caused by the variation in density, is different for each range.

Column 12, of the range table, is headed "Change of Range for a Variation of Density of Air of plus or minus 10%." Assuming a range of 10,000 yards for a standard 12-inch projectile, enter column 12, and find that for a range of 10,000 yards, ± 10% variation in the density of the air will give a change of range of 215 yards; that is, if our density had been (1.10) or 10% above normal, and the range scale setting had been 10,000 yards, our projectile

would have actually traveled only 10,000 − 215 or 9785 yards; if our density, on the other hand, had been (0.90) or 10% below normal, our projectile would have actually traveled 10,000 + 215 or 10,215 yards, with the range scale set at 10,000 yards.

10% change in density at 10,000 yards = 215 yards.

∴ 5% change = $\frac{5}{10} \times 215 = 107.5$ yards, which is the change in range at 10,000 yards for the assumed density of (0.95).

Our air is lighter than normal, so less resistance was offered to the flight of our projectile; therefore it would actually have traveled **107.5 yards over** if we had fired our gun with the range set at 10,000 yards, which was our range-finder reading at the instant.

CHANGE IN INITIAL VELOCITY OF PROJECTILE DUE TO EROSION OF GUN BORE, ETC. As has been stated before, all range tables are based on a certain initial velocity of projectile in feet per second. **Any variation in this initial velocity, however slight, will cause a corresponding change of range.**

The usual cause of a reduction in the initial velocity of a projectile is **the erosion of the gun bore, or a wearing down of the rifling**, due to the heat and pressures generated by the explosion of the powder charge during a number of rounds of firing. **The bore and rifling should be frequently inspected by the divisional officer, especially before firing**, to determine if its condition will cause a reduction of the initial velocity. If it will, the amount of the reduction should be judged by the amount of wear, etc., and calculated on for that firing, or, if there is time, and an opportunity, you can "test fire" the gun on a measured range and on a calm day, under known conditions. The amount the projectile falls short of the proper range, as the average result of several rounds, will enable you to figure the change in the initial velocity.

Assume that our gun bore is so eroded that our projectile leaves the muzzle with an i. v. of only 2825 feet per second, while our range table is computed on an i. v. of 2900 feet per second; then our i. v. is reduced by 75 feet per second.

Column 10, range table, is headed, " Change of Range for a Variation of plus or minus 50 feet per second Initial Velocity." Assuming still the same range-finder range of 10,000 yards, we look for this in our range table, and opposite, in column 10, find that a variation of $\pm$ 50 ft./sec. i. v. gives a change in range of 277 yards; that is, if we set 10,000 yards on our range scale and fired, our projectile would travel only 10,000−277 or 9723 yards if our i. v. was reduced to the extent of 50 feet per second.

Our i. v. is actually reduced 75 feet per second at this range, $\therefore \frac{75}{50} \times 277 = 415.5$ yards.

Therefore, with this reduced i. v. of 75 feet per second, if we had fired our gun with range set at 10,000 yards, our projectile would have actually traveled or landed **415.5 yards short.**

It must be kept in mind that this correction must be figured separately for each individual gun, as in each gun the rifling and the i. v. may be different, if other than normal.

CHANGE IN RANGE DUE TO VARIATIONS IN THE TEMPERATURE OF OUR POWDER. Our range tables are computed on a standard temperature of powder of 90° F. A powder charge loaded in a gun and fired at a higher temperature than 90° F. will give an increased i. v. of projectile, and, consequently, an increased range. Powder below 90° F. in temperature will give a reduced i. v. and a shorter range.

90° F. is the usual basis taken for the temperature of the powder, because experience shows this to be the lowest temperature at which powder can be consistently maintained under all conditions and on board all of the various types of ships in the Service. With the methods of ventilating and refrigerating magazines in use on our modern ships, powder can be kept at a much lower average temperature and will have a longer life for this reason, as 90° F. is a temperature at which smokeless powder will, sooner or later, decompose. The powder charges are brought from the magazines one at a time, as needed, and are loaded immediately into the gun; they can be considered, therefore, to be of the same temperature as the magazine from which they are taken.

The main difficulty in allowing for variations of the temperature of the powder is that all magazines of the ship, containing powder for the same caliber guns, are not always at the same temperature, so that the guns they supply will have different range errors.

The effort, therefore, must be constant to keep our magazines at a uniform temperature, in order that in our control of fire, our figures on the change of range, caused by the variation from standard in the temperature of our powder, will be the same for all guns of the same caliber on board the ship.

A change in the temperature of the powder causes first a change in the initial velocity of the projectile. On the first explanatory page of every range table, it will state the standard temperature of powder on which the table is based, **and state also the change in the initial velocity of the projectile that will be caused by a variation of plus or minus 10° F. in the powder temperature.**

Assuming a 12-inch, 2900 ft./sec. i. v. range table as before, the standard temperature of the powder will be 90° F., and the change in i. v. for ± 10° F. will be 35 feet per second.

If the temperature of our powder, as taken from the magazine, should be 95° F., it would be 5° F. above normal. An increase of 10° F. in our temperature will cause our projectile to leave the gun muzzle at a rate of 35 ft. /sec. faster than 2900 ft./sec.

5° F. will cause it to leave at a rate $\frac{5}{10} \times 35 = 17.5$ ft./sec. above normal.

Now we have to consider merely an increase in our i. v. such as we have considered before in connection with the erosion of our gun bore.

Column 10 gives us, for a range of 10,000 yards, a change of range of 277 yards to correspond to ± 50 ft./sec. i. v.

$\therefore \frac{17.5}{50} \times 277 = 96.95$ yards, which is the distance that our projectile will fall over or beyond the target with a powder 5° F. above normal in temperature when the range is set at 10,000 yards.

VARIATIONS IN WEIGHT AND FORM OF PROJECTILE. All projectiles now issued to the Service for use are of standard weight and are very carefully inspected before leaving the manufacturer to insure this weight being exact. The actual weight in pounds is stamped on the rotating band of every projectile, together with the initials of the inspector and other data. The weight stamped on the projectile should be the same as the standard weight on which the range table that we are using is computed;—in this case, for a 12-inch table, i. v.–2900 feet / sec., the weight of projectile is 870 pounds.

It seems perfectly evident to any one that, other things being equal, two projectiles of slightly different weights will leave the bore of a gun at different initial velocities, the lighter projectile having the greater muzzle velocity; also they will have different ranges or will travel different distances — **the lighter projectile having the greater range.**

This is true in the great majority of cases — **a light projectile will go farther and a heavy projectile will travel a shorter distance.** However, there are certain conditions under which a projectile over weight will travel farther than one under weight — due to the particular form of the projectile and the momentum attained by it. In the few instances where this occurs, the figures in the range table for a change in range due to variation in weight of projectile are preceded by a minus (–) sign. No sign indicates that a heavier than standard projectile has a shorter range and a lighter one a longer range.

While, as stated, the inspection of projectiles before issuance is now so strict that errors in weight need not be expected, it may be found at some time that a certain lot is slightly under or over weight and in this case a table is provided to compensate for it.

Column 11 gives the "Change in Range for a Variation of Weight of Projectile."

Assuming still our 12-inch gun and a range of 10,000 yards, a variation of 10 pounds in our projectile causes a change in the range of 42 yards.

If our projectile weighs 877 pounds, or $877-870=7$ pounds above normal, then $\frac{7}{10} \times 42 = 29.4$ yards, which is the amount our projectile will fall short due to its being overweight, when fired at a range setting of 10,000 yards.

When projectiles of different coefficients of form are supplied, not only will there be a divergence in the range of the projectiles, but also in the amount of their drift. An illustration of different coefficients of form is represented by the armor-piercing shell with its long blunt-pointed cap and the common shell for the same caliber gun having an ogival head and point. These projectiles fired from the same gun and with an equal powder charge, etc., will differ in their range and the amount of their drift.

To allow for this, different range and deflection strips are used. These are furnished to a ship when projectiles of different types are supplied. Each set of strips is graduated for the particular type of projectile with which it is to be used. The strips can be quickly interchanged.

WIND ON THE RANGE OR CROSSING THE PLANE OF FIRE. The **plane of fire** can be represented by a vertical plane passing through the trajectory or through the actual path followed by the projectile in the air, not allowing for any deflection to right or left. **It can also be defined as the line of bearing between firing and target ships at the moment of opening fire.**

A wind traveling over the surface of the water and crossing the plane of fire has a direct effect on the projectile in its trajectory, depending on the force of the wind.

A wind is judged as to its speed in knots per hour as it crosses the observer's position or crosses the plane of fire.

REAL WIND: Assuming that our firing ship is anchored, a projectile fired from the muzzle of a gun on the ship would be affected by the force of the real wind; that is, the actual force of the wind in knots per hour.

APPARENT WIND: Assume, now, that the firing ship is traveling in the same direction as the real wind. If the real wind has a force of 12 knots per hour from the south or blowing toward north, and the ship is traveling at a rate of 6 knots

per hour on a course north, or in the same direction, then the apparent wind on the ship would be 12+6 or 18 knots apparent wind. A projectile fired under these conditions would be affected then by the apparent wind of 18 knots. If the firing ship were traveling in the face of the real wind, the apparent wind would be the difference or 12 − 6 = 6 knots per hour.

In this discussion we will always consider the effect of the real wind, assuming, when allowing for the corrections due to the force of the wind, that both firing and target ships are stationary.

Column 13, range tables, is headed, "Change of Range for Wind Component in Plane of Fire of 12 Knots."

The table is based on a standard force of the wind of 12 knots. At a range of 10,000 yards, a 12-inch projectile will travel 27 yards farther with a wind component or with a wind behind it at a force of 12 knots per hour than it would in a calm. If the projectile had to travel against the same wind, it would actually go 27 yards less than 10,000 yards.

If our real wind had been at the rate of 18 knots in the direction of travel of the projectile, our range would have been increased $\frac{18}{12} \times 27 = 40.5$ yards, which is the distance our projectile would have fallen beyond the target with range scale at 10,000.

PERSONAL ERRORS OF POINTING, ETC. Personal errors of pointing, sight-setting, etc., we cannot compensate for. The only way to avoid such errors is by constant practice and training of the gun-pointer group.

The most frequent error is that caused by the gun-pointer not having his cross-wires "on" when the projectile leaves the gun-muzzle, and this is due usually to his failure to "follow through" or "keep on" after he has pressed his firing-key, and during the whole interval during which the projectile is passing down the gun bore.

PRINCIPAL ERRORS OF "DEFLECTION"

Drift of projectile has already been discussed in connection with "**Gun Sights and Mechanisms.**" It is the inclina-

tion of a projectile to drift or change its course slightly to the right, and to an extent increasing with the range; this drift being occasioned by the clockwise revolution of the projectile about its axis imparted by the rifling of the gun bore. The drift increases proportionally with the range, inasmuch as the velocity of the projectile falls off rapidly as longer ranges are approached. **The drift of a projectile is always to the right of the plane of fire.**

Deflection scales graduated in knots compensate on the scale for the drift of projectile, the lines or divisions on the scale curving to the left to compensate for a drift of projectile to the right. Then, using the knot scale, based on a speed of the target ship of two knots per hour for each division, we need not bother with the drift.

An arbitrary deflection scale, on the other hand, does not take drift into consideration. When using this type of scale, therefore, we must allow for our drift. At a range of 10,000 yards our table gives us figures for the drift of a 12-inch projectile — 19 yards. **Fired at 10,000 yards, then, and with deflection at 50, our projectile will fall in the water 19 yards to the right of the target, due to its drift.**

WIND CORRECTION: We have already considered the effect of a real wind in or parallel to the plane of fire and have noted the change in range occasioned by it.

Now let us consider a real wind blowing across our plane of fire at right angles or perpendicular to it.

Column 16, range tables, is headed, "DEVIATION FOR LATERAL WIND COMPONENT OF 12 KNOTS." For a range of 10,000 yards we find, from column 16, that a wind of 12 knots will deflect our projectile to the right or left of the target a distance of 14 yards, depending on which side of the projectile the wind is blowing.

Our plane of fire is north and south. **If our wind is from the east at 15 knots per hour, the projectile will fall $\frac{15}{12} \times 14 =$ 17.5 yards to the left of the target, due to a wind on its right side.**

VARIATION IN INITIAL RANGE AND DEFLECTION DUE TO DIFFERENT COURSES AND SPEEDS OF FIRING AND TARGET SHIPS

THE FIRING SHIP: The range tables give us data for the effect, on the range, of the motion of the firing ship or gun in or parallel to the plane of fire; also the effect on deflection of the motion of the firing ship or gun across or perpendicular to the plane of fire.

CHANGE OF RANGE — Motion of Gun in Plane of Fire: The direction of motion of the ship when it fires a gun either increases or decreases the range of the projectile as the gun is traveling toward or away from the target. This is effected by the motion of the ship being taken up by the projectile and also, to a slight extent, by the distance traveled by the gun during the firing interval, or between the time the firing-key is pressed and the time the projectile issues from the gun muzzle.

Column 14, range table, is headed, "Change of Range for Motion of Gun in Plane of Fire of 12 Knots." Our 12-inch table, for a range of 10,000 yards, gives a change in range of 57 yards for a speed of 12 knots. This means that if we fired at the instant the target was 10,000 yards away and kept on steaming directly toward the target at a rate of 12 knots, our projectile would fall 57 yards over or beyond the target due to its taking up the motion of the ship and to the distance traveled by the firing ship during the firing interval and while the projectile traveled down the gun bore. **If our ship had been traveling at 18 knots per hour away from the target, we would have had $\frac{18}{12} \times 57$ yards $= 85.5$ yards, which is the distance the projectile would have fallen short of the target at a range setting of 10,000.**

CHANGE OF DEFLECTION — Motion of Gun across Plane of Fire: A direction of motion of the firing ship and gun across the plane of fire on a line or course perpendicular to it causes the projectile to fall to the right or left of the target, depending on the direction of motion of the ship. This is effected, as was the change in range, by the motion of the ship

being taken up by the projectile and also by the distance traveled by the firing ship during the firing interval and while the projectile was traveling down the gun bore.

Column 17, range table, is headed, "Deviation for Lateral Motion of Gun Perpendicular to Plane of Fire, Speed of 12 Knots." Our 12-inch table for a range 10,000 yards gives a deflection of projectile of 70 yards to the right or left of the target due to a speed of ship of 12 knots. This means that if we fired at the instant the target was 10,000 yards away and bearing directly north and we continued to steam east at the rate of 12 knots, our projectile would fall 70 yards to the right of the target.

If our ship had been traveling at 18 knots per hour due east while the target bore north, we would have had $\frac{18}{12} \times 70 = 105$ yards, which is the distance our projectile would have fallen to the right at a deflection setting of 50.

It is an interesting and important point that the **figures given in columns 14 and 17 contain allowances based on the force of the apparent wind.**

Take our deflection, for example; if our firing ship travels at the rate of 10 knots an hour, and fires at a target, the projectile would take up the motion of the ship. If the ship fired in a vacuum, the projectile, after it left the gun, would make good, **in deflection,** practically the same distance as that traveled by the ship during the time of flight of the projectile. However, we are not firing in a vacuum, but in still air, and this creates an apparent wind of 10 knots, which bears on the left side of the projectile, in this case, and thus reduces the deflection.

In calculating changes in range and deflection due to motion of the firing ship, always consider for the purpose that the target ship is anchored or fixed. This will save you many errors in naming corrections "over" or "short," "right" or "left."

THE TARGET SHIP: The range tables also give us data for the effect on the range, of the motion of the target in or parallel to the plane of fire, and for the effect on deflection of

the motion of the target across or perpendicular to the plane of fire.

CHANGE OF RANGE — Motion of Target in Plane of Fire: The data in this column is based on the actual time of flight of the projectile in covering a certain range. During this time of flight, the target ship can travel a certain distance away from or toward the firing ship, and the projectile will miss the target by this distance unless it has been allowed for in setting the sights.

Column 15, range table, is headed, "Change of Range for Motion of Target in Plane of Fire of 12 Knots." Our 12-inch table for a range of 10,000 yards gives a correction or a change in range of 84 yards for a speed of 12 knots. This means that if we fired on the instant the target was 10,000 yards away, and that if, during the time it took for the projectile to travel those 10,000 yards in range, the target ship continued steaming directly away from the firing ship, the projectile would drop in the water 84 yards behind the target, or short. The target traveled 84 yards in the time of flight of the projectile.

If our target had been traveling at 10 knots per hour away from the gun we would have had $\frac{10}{12} \times 84$ yards $= 70$ yards, which is the distance the projectile would have fallen short of the target at the range setting of 10,000.

CHANGE OF DEFLECTION — Motion of Target across Plane of Fire: The data in this column is likewise based on the time of flight of the projectile in covering a certain range. During this time of flight, the target ship can steam a certain distance to the right or left of the plane of fire and the projectile will miss it by this distance, unless it has been allowed for in setting the sights. The figures in this column are identical with those given in column 15, which is based on a change of range.

Column 18, range table, is headed "Deviation for Lateral Motion of Target, Perpendicular to Plane of Fire, Speed of 12 Knots." Our 12-inch range table for a range of 10,000 yards gives a correction, or a deviation in the plane of the target, of 84 yards due to the motion of the target across the

plane of fire at a rate of 12 knots. This means that if we fire on the instant the target bears due north from the gun and distant 10,000 yards, while the target ship is steaming west at the rate of 12 knots, the target ship will actually cover 84 yards to the left of the plane of fire during the time the projectile is covering 10,000 yards range, which time is 12.43 seconds.

If our target had been traveling West at 16 knots per hour across a plane of fire bearing North and South we would have had $\frac{16}{12} \times 84 = 112$ yards which is the distance the projectile would have fallen to the right of the new position of the target at a deflection setting of 50.

In calculating changes in initial range and deflection due to motion of the target ship, always consider, for this purpose, that the firing ship is fixed or anchored while the target is moving.

CORRECTION FOR COURSES OF FIRING AND TARGET SHIPS OTHER THAN PERPENDICULAR AND PARALLEL TO THE PLANE OF FIRE

Up to the present time we have been considering only those cases where our firing and target ships have been steaming on courses perpendicular and parallel to the plane of fire, these being the standard conditions on which our range tables are based.

Actually, in practice, an ideal situation like this would rarely exist. Always the two ships will be traveling on diverging or converging courses at the moment of firing.

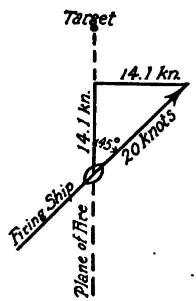
The course of our own, the firing ship, we know; also our course with relation of the plane of fire. The course and speed of the enemy ship we have already determined from our range-finder readings and bearings, and from this we can quickly determine the course of the enemy ship across the plane of fire.

Having found the angle that the course of each ship makes with the plane of fire and knowing the speed that each is

making on this course, **we must, by the solution of a plane right triangle, find the corresponding speed of each on courses perpendicular and parallel to the plane of fire, in order that we may use our range tables.**

Let us take, for example, the firing ship. Assume that she crosses the plane of fire at an angle of 45° and at a speed of 20 knots per hour.

Then, referring to the diagram, the solution of the triangle shows that while the ship is crossing the plane of fire at an angle of 45° and at a rate of 20 knots per hour, she also is traveling across the plane of fire (perpendicular component) at the rate of 14.1 knots per hour, and in the plane of fire (parallel component) at the rate of 14.1 knots per hour.



If our angle had been 30 degrees and the speed the same, our solution would show that while crossing the plane of fire at an angle of 30 degrees and at a rate of 20 knots per hour, our ship would also be traveling perpendicular to the plane of fire at a rate of 10 knots per hour and parallel to it at a rate of 17.3 knots per hour.

TRAVERSE TABLES: The solution of the plane triangle referred to can be most easily effected by reference to "**Bowditch's Useful Tables**" or "**Bowditch's American Practical Navigator.**" **Table #2** is commonly referred to as a "**Traverse Table**" because its usual use is in working "**Traverse Sailing**" in "**Navigation.**"

It amounts practically, however, to nothing more nor less than a solution of a series of plane right triangles, and as such it is admirable for our purpose.

Taking your angle of bearing at the top or bottom of the page, — top, if the angle is less than 45°, and bottom, if it is over 45°, — enter in the column marked "**distance**" with your actual speed, and opposite in the column marked "**latitude**" you will find your "north and south" or "parallel" component. In the column marked "**departure**" you

will find your "east and west" or "**perpendicular**" component.

When the angles are taken from the bottom of the page, the headings of the columns are reversed. Be sure you look carefully at the headings of the columns and at the top or bottom of the page according as the angle is at the top or bottom.

Taking, for example, our angle of 30 degrees and speed of 20 knots. At the top of the page headed 30°, look for 20 in the distance column; opposite in the latitude column, we find 17.3, our parallel component, and in the departure column 10.0, our perpendicular component.

The solution of these triangles can be done by trigonometry, if desired, or by using Table #41, Bowditch, the "Natural Sines and Cosines." However, the traverse tables give the quickest and easiest solution and are accurate enough for all practical purposes.

The wind crossing the plane of fire at an angle is also resolved into parallel and perpendicular components, as described in the foregoing.

SPECIMEN PROBLEM TO DETERMINE INITIAL RANGE AND DEFLECTION

You are Chief Fire Control Officer of a battleship and the Captain has ordered you to open fire on the enemy ship with your 12-inch battery, the instant the enemy bears due north from you and is distant by range-finder 10,000 yards. The course and speed of the enemy ship has been plotted to be 20 degrees (true) and 15 knots. Your own course are 300 degrees (true), and speed 16 knots. The above data is known to you a sufficient time in advance to figure variations from standard conditions to be allowed for in setting your sights. Barometer 29.00 inches. Thermometer 75° F. Temperature of powder is 95° F. A real wind from the southeast is blowing across the water at an estimated rate of 20 knots per hour.

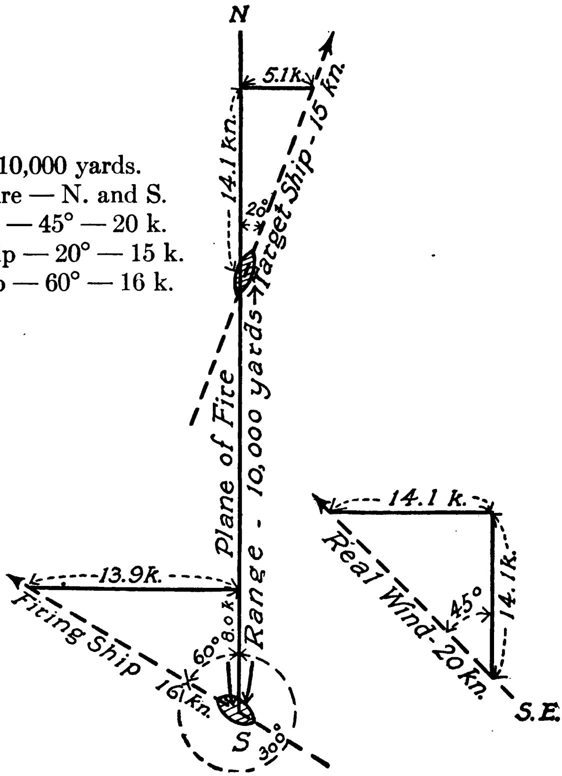
What would be the actual range and deflection to be set on the sight scales, to hit the enemy the first shot?

Assume (1) that the deflection scale is graduated in "knots, speed of target," and (2) on the "Arbitrary" basis.

SOLUTION

First, draw a rough diagram representing all possible conditions and based on a north and south line. **In this particular case, our plane of fire will also be north and south, inasmuch as we open fire when the enemy bears due north from us.**

Range — 10,000 yards.
Plane of fire — N. and S.
Real wind — 45° — 20 k.
Target ship — 20° — 15 k.
Firing ship — 60° — 16 k.



BY TRAVERSE TABLES

Firing Ship

Course (60°), Speed 16 knots
Rate perpendicular to plane of fire — 13.9 k.
Rate parallel to plane of fire — 8.0 k.

Target Ship

Course (20°), Speed 15 knots
Rate perpendicular to plane of fire — 5.1 k.
Rate parallel to plane of fire — 14.1 k.

Real Wind

From S.E. (45°), Rate 20 knots
Rate perpendicular to plane of fire = 14.1 k.
Rate parallel to plane of fire = 14.1 k.

RANGE TABLES — 12-Inch i. v. 2900 ft./sec.

FIRING SHIP

Column 14 — Change of Range for Motion of Gun in Plane of Fire

10,000 yards and 12 knots = 57 yards

$\frac{8}{12} \times 57 = 38$ yards (over)

Column 17 — Deviation for Lateral Motion of Gun Perpendicular to Plane of Fire

10,000 yards and 12 knots = 70 yards

$\frac{13.9}{12} \times 70$ yards $= 81.1$ yards (left)

TARGET SHIP

Column 15 — Change of Range for Motion of Target in Plane of Fire

10,000 yards and 12 knots = 84 yards

$\frac{14.1}{12} \times 84 = 98.7$ yards (short)

Column 18 — Deviation for Lateral Motion of Target Perpendicular to Line of Fire

10,000 yards and 12 knots = 84 yards

$\frac{5.1}{12} \times 84 = 35.7$ yards (left)

REAL WIND

Column 13 — Change of Range for Wind Component in Plane of Fire

10,000 yards and 12 knots = 27 yards

$\frac{14.1}{21} \times 27 = 31.7$ yards (over)

Column 16 — Deviation for Lateral Wind Component

10,000 yards and 12 knots = 14 yards

$\frac{14.1}{12} \times 14 = 16.5$ yards (left)

ALGER'S EXTERIOR BALLISTICS

$\left.\begin{array}{l}\textbf{Table III} \text{ — Barometer 29.00 inches} \\ \qquad\qquad \text{Thermometer 75° F.}\end{array}\right\}$ Density 0.95

Normal density = 1.00
Density at firing = 0.95
.05 = 5% below normal

RANGE TABLES

DENSITY OF AIR

Column 12 — Change of Range for Variation of Density of Air ± 10 per cent

10,000 yards = 215 yards

5% = $\frac{5}{10} \times 215 = 107.5$ yards (over)

TEMPERATURE OF POWDER. The explanatory page in the front of our range table tells us the normal temperature of powder on which the table is based; also the variation in the initial velocity for ± 10 degrees in variation of this temperature from normal.

Normal powder = 90° F.

Variation in i. v. for change in powder temperature of 10° F. = 35 feet/second.

Our powder = 95° F.
Normal powder = 90° F.
5° F. above normal

$\frac{5}{10} \times 35$ ft./sec. = 17.5 ft./sec. **i. v. increased**

Column 10 — Change of Range for a Variation of ± 50 Foot-Seconds Initial Velocity.

10,000 yards gives 277 yards

$\frac{17.5}{50} \times 277 = 96.9$ yards (**over**)

	Over	Short	Right	Left
Ship—Parallel . . .	38	—	—	—
Ship—Perpendicular .	—	—	—	81.1
Target—Parallel . .	—	98.7	—	—
Target—Perpendicular	—	—	—	35.7
Wind—Parallel. . .	31.7	—	—	—
Wind—Perpendicular	—	—	—	16.5
Density	107.5	—	—	—
Temp. Powder . . .	96.9	—	—	—
	274.12	98.7		133.3
	98.7			(left)
	175.4			
	(over)			

RANGE:

175.4 yards over; that is, if we fired with range scale set at 10,000 yards, our projectile would have gone beyond the target ship 175.4 yards. Therefore, to make a hit we reduce our range

10,000 − 175.4 = **9824.6 yards, actual or exact range**

Our range strip is, however, graduated only in 50 yard divisions, so what we call the " service setting " is taken to the nearest division, and if midway between two 50-yard divisions, it is better to shoot low than high, so take the lower division.

Service Setting — 9800 yards.

DEFLECTION 133.3 yards left.

Our deflection scale is graduated in knots, speed of target, so we must reduce this 133.3 yards to knots on the plane of

the target, in order to determine the number of divisions to shift our azimuth or deflection drum.

Column 18, range tables, gives data, that at a range of 10,000 yards and a speed of 12 knots the target will travel 84 yards, to right or left of the plane of fire.

This gives us the relation in the plane of the target between a knot and a yard.

$$12 \text{ knots} = 84 \text{ yards}$$
$$1 \text{ yard} = \tfrac{12}{84} \text{ k.}$$
$$133.3 \text{ yards} = \tfrac{12}{84} \times 133.3 = 19.04 \text{ k.}$$

If we had fired with a deflection setting of 50, then, our projectile would have landed to the left of the target 133.3 yards or 19.04 knots. **To cause our first shot to hit, we move our deflection setting in the same direction as that toward which we want to bring the point of fall of the projectile, to the right in this case.**

50 + 19.04 = 69.04 **Deflection — Exact**
69 **Service**

DEFLECTION — ARBITRARY SCALE

Column 6, range table, gives a drift of projectile of 19 yards. This is always toward the right.

Therefore 133.3 yards left
− 19 yards right
114.3 yards, total deflection for arbitrary scale.

At 10,000 yards range, one division on our deflection scale will correct 10 yards of deviation of projectile, if it corrects 1 yard at 1000 yards range.

$\therefore \dfrac{114.3}{10} = 11.43$ **divisions on arbitrary drum will correct 114.3 yards of deviation.**

50 + 11.43 = 61.43 **Exact**
50 + 11 = 61 **Service**

Answers { **Range 6800 yards** / **Knot Deflection 69** / **Arbitrary Deflection 61** }

With these settings we should, theoretically, hit the target with the first shot.

Hot and Cold Guns:

A slight error in range is always occasioned by the fact that the guns when the first shot is fired are cold and after that they are very hot.

This error is comparatively small and usually is not considered.

CALIBRATION OF GUNS

By calibration of a gun we mean checking it up by firing under standard conditions, with ship stationary and at a stationary target bearing abeam. A day is selected when there is no appreciable wind, density is nearly normal, and water is calm. Other conditions are brought as nearly to standard as possible. The ship is trimmed on an even keel and the gun mount checked for accuracy; gun is bore-sighted at exact range.

A number of shots are fired and the mean point of their impact on the target is determined. The distance of this mean point of impact from the bull's-eye of the target, as the point of aim, is **the constant error of the gun**, and must be allowed for in every firing thereafter. This constant error may be due to various causes, principally faulty installation of the gun.

Chapter XVIII

FIRE CONTROL

BRIEF OUTLINE OF THE SYSTEM FOR CONTROL OF FIRE ON A CAPITAL SHIP—CONTINUOUS DETERMINATION OF RANGE AND DEFLECTION — SALVO FIRING

FIRE–CONTROL, as a term, refers to the method adopted and followed on board a naval vessel, **to direct and control the firing of its guns.**

In its true sense, it is a broad term **applying not only to the organization of the personnel of a ship for the purpose of firing the guns so that the enemy ship or objective will be hit accurately and rapidly; but also to the material, or the entire equipment of the ship brought into operation in connection with the use and control of the battery.**

Thus, we have a **fire-control organization**, which contemplates a definite station and definite duties for every officer and enlisted man on the ship during any manner of engagement, which might possibly bring any gun of the ship into action; also we have the **fire-control apparatus**, which includes all the mechanical and electrical equipment of the ship, utilized by the personnel in their control of the fire.

The method of the control of the fire varies, of course, on different ships in the Service, to the extent made necessary by the number and caliber of the guns carried, and by the interior arrangement and equipment of the different ships.

For this reason it is possible to discuss methods of fire control in general terms only.

In addition, the details of any particular methods of fire-

control are desired by the Navy Department to be kept secret, and are not to be divulged to any one except officers and enlisted men of the Service, and then, in a confidential manner only.

This discussion therefore is to be considered as covering the subject only in the very broadest way, the aim being merely to give the reader a good conception of what we mean by "fire-control."

BATTLE STATION AND QUARTER BILL

This bill, usually called a "Quarter Bill", is the basis of the ship's organization for its conduct in action. Primarily it is the basis of the fire-control organization.

Essentially, the bill is a tabulation of the stations and duties of every officer, man, or group of men, on the ship, to be occupied or performed by them during such time as the vessel is engaged in action; such as "battle action" or "torpedo defense."

Each man's duties are set forth definitely and in sufficient detail to cover most of the conditions that might come up during the course of a battle action.

Casualties to personnel and material are anticipated, and secondary control stations and others are stipulated; also reliefs are designated for all important stations.

Day and night actions are covered, as are also various conditions of battle, as follows: concentration of all guns on one target; on two targets on same side of firing vessel; on two targets on opposite sides; direction and control of torpedo defense battery on attacking destroyers or submarines, etc. In short, every possible contingency that might come up during an engagement is provided for.

The detail stations included in the "Quarter Bill" are given later, in the discussion on "Battle Drills."

The Quarter Bill is drawn up and prepared as a rule by the ship's "Gunnery Officer." Before being issued, it is submitted to the Executive and Commanding Officers for approval.

INITIAL RANGE AND DEFLECTION

The subject of the determination of initial range and deflection has already been covered in detail in connection with "Elementary Gunnery", but it is brought up again briefly at this time, to make more clear the subject of "Fire-Control", on which it has an important bearing.

With our present 12, 14, and 16-inch high-power rifles, mounted on the new super-dreadnought class of ships, it is fair to assume that a modern naval engagement will be fought out at such long ranges that the medium-caliber broadside guns will never be within effective range, and so will have no part in the action.

All of these new super-dreadnoughts are designated "all big-gun ships", for the reason that their batteries consist solely of all big guns of uniform caliber, mounted in turrets. The only guns carried in addition to the main battery are usually a torpedo-defense, broadside battery of five-inch guns, and a secondary battery of three-inch semi-automatic guns.

For a ship of this type, therefore, the present system of fire-control for a long-range engagement anticipates the use of the main battery only.

If the range should ever be reduced to such an extent that the 5-inch battery could get into action, a separate, individual method of fire-control for it is provided.

Let us consider the fire-control system for the main battery only of a large ship.

RANGE-FINDER GROUP

The range-finder gives us, fairly accurately, the distance of the enemy ship at the instant of observation, the reading on the range-finder being direct in yards.

In the newest ships, the range-finder mechanism is mounted in the turrets themselves, the lenses being located in arms which project a short distance sideways, one from each side of the front of the turret. In the older type of battleships, having two turrets, one forward and one aft, a range-finder is mounted on the top of each turret.

The range-finder group consists of an officer and several men, well-trained in the practical use of the instrument and having especially keen eyesight.

When an enemy ship is first sighted, they take station at the most reliable range-finder on the ship and use this. In the event of casualty to it, they either shift to another instrument, or the work is taken up by another crew stationed at the other range-finder.

When the enemy ship is first sighted, and at the direction of the fire-control officer, a range-finder reading is taken to determine her distance, and the time noted by stop-watch. Also the bearing of the enemy vessel is taken at the same instant, with a contrivance called a "bearing indicator." At intervals of 30 seconds from the first range and bearing, and from each other, take a series of ranges and bearings. By plotting each consecutive range and bearing at the proper time interval distance from each other, you can establish on a chart a series of fixes, or positions of the enemy ship at various short intervals. A line drawn carefully through these fixes will give the course of the enemy, and from it you can also determine his rate of speed. **This is designated as the "determination of the course and speed of the enemy."**

The actual determination of this course and speed is worked out in a station below decks, called the **plotting-room,** the ranges and bearings and the time intervals being communicated to the plotting-room by the range-finder group. As soon as the course and speed is found accurately, it is transmitted to the fire-control officer in order that he may make such calculations as are necessary to determine the initial range and deflection at which to open fire, allowing for all conditions at the time that are other than standard.

FIRE-CONTROL STATION

This is the station in battle of the "CHIEF FIRE-CONTROL OFFICER," who is also the "Gunnery Officer" of the ship. From this station he controls and directs the firing of all the guns of the ship, designating the point

of aim of the guns, either all on one target, or on several targets, as necessity dictates. **He gives the electric firing signals from this station,** by what is known as the master-switch, operating all firing signals in the ship.

The fire-control station on the newest ships is located directly over the conning tower, which is the battle station of the commanding officer of the ship. On other ships it is located at the base of the foremast, on the bridge, or on the upper bridge, when there is one.

The essential requirement is that the " fire-control station " must be in direct communication with the conning tower, which we call " ship control station." It is perfectly evident that the best results will be obtained only by the coördination of the ship and fire control.

The Commanding Officer, in " Ship Control ", is also immediately advised of the speed and course of the enemy as soon as this is determined. If the ship is operating singly, the Commanding Officer after a study of the situation will advise the Fire Control Officer when to open fire, and how.

The command might be given in this manner: " Open fire at the enemy ship when she bears North-East and is distant 12,000 yards, using your 12-inch guns in salvo."

The Fire-Control Officer will immediately calculate the initial range and deflection to be set on sight-bar and azimuth drum, making allowances for all conditions other than standard at the time, and for known errors of individual guns. These calculations will be made by the solution of problems similar to that covered in " Elementary Gunnery ", or, in modern ships, they can be made with the aid of certain ingenious mechanical and electrical contrivances.

The initial range and deflection, as soon as determined, is communicated to the " plotting room." Here it is immediately plotted on charts with relation to the course and speed of the enemy. **From the plotting room the range and deflection is sent to each gun and turret, and the sights are set accordingly.** The range and deflection is sent to the guns by three different methods to avoid any possibility of confusion: by telephone, voice tube, and by " visual "

indicator. Each turret or gun reports back "**set**" as soon as the sights are ready.

The fire control officer, after receiving the report, "**set**", watches closely the enemy ship. When she is nearly on the predetermined line of bearing, by operation of his master switch, he causes the "**buzzer**" **to sound in each turret or at each gun.** At the instant the enemy ship is on the line of bearing, in this case north-east, he causes the "**bell**" **to ring at each gun or in each turret. The buzzer signal means "stand by to fire." The bell signal means "fire."** There is usually an interval of about five seconds between the two signals.

The exact instant of sounding the bell firing signal must be carefully judged by the fire-control officer, not only as regards the bearing of the enemy ship at the instant, but also as regards the motion of the ship. Range and deflection are both greatly affected by undue motion of the firing vessel: pitching and rolling. The signal should be given at such a time as the ship is steady longest in one position, such as the top or bottom of the roll.

At the firing signal, all guns fire in salvo or together, unless certain ones have been previously designated not to fire.

Each turret, battery, or group of guns is usually fitted with a "relay switch" on the firing signal system. If for any reason certain guns are not to fire on the signal, by pulling this relay switch, the turret or battery officer cuts out the bell and buzzer at the particular turret or group of guns.

RANGING SHOTS: The foregoing has been based on all guns of the ship being fired together, or in salvo, at initial range and deflection. When the initial range and deflection can be determined with any degree of accuracy, the first salvo may strike and demoralize the enemy, and an important advantage be scored.

On the other hand, if it is impossible to determine the initial range and deflection with any degree of accuracy, **ranging shots** are resorted to. **Instead of firing together, the guns of a broadside are designated to fire singly, and in succession, at certain intervals.** By means of "**spotters**"

we judge the landing place of each shell with reference to the enemy ship and correct the next range and deflection until the target is "found." **Then take up firing in salvo.**

COLLECTIVE SHIP CONTROL

The method of opening fire covered in the foregoing has presumed the ship to be acting singly, under the control of its own commanding officer. In a modern engagement there is no doubt but that the single ships would be under the control of a flag officer having station on the flag ship of the division, fleet, battleship force, etc.

In this case directions for opening fire would come from the flag ship, as would also directions for continuing it. The interior system of fire-control would, however, be the same as has been outlined.

SPOTTER'S GROUP

Our range-finders and other mechanical and electrical instruments would be ideal for giving us at any instant the exact range, course, and speed, etc., of the enemy if they could compensate also for the various errors of gun-fire with which we have to contend.

Certain of these errors of gun-fire are variable and indeterminate in an exact sense, and for this reason we are compelled to resort to individual spotting, or judging of the landing place of each shell or salvo of shells fired.

Spotters for long-range firing are stationed usually in the "tops" of the cage masts, the aim being to give them the advantage of the most elevated position in the ship. An officer especially trained in "spotting" is stationed in each top, and is designated Spot #1 and Spot #2, respectively, for fore and main-masts. Each spotting officer has with him several men stationed at voice tubes and telephones to plotting-room, fire-control, etc. In action, with all guns firing at one target, Spot #1 does all the spotting. In case of casualty to him, Spot #2 continues. Where the fire of a ship is divided on two targets, each spotter controls one group of guns.

The duties of a spotter are to keep a constant, close watch on the target or enemy ship, and by various methods to judge as accurately as possible the point of fall of a single shell, or the mean point of fall of a salvo of shells with reference to the objective. A quick determination is made of the change in range and deflection necessary to make the next shot or salvo score a hit, assuming of course that both firing and target ships remained in the same position, without advancing, until the next salvo could be fired.

Immediately after each shot or salvo, the spotter telephones to the plotting room the result of his spot, giving the corrections in range and deflection direct.

Of course, both vessels are moving and so change their relative positions, so that the "spots" cannot be placed directly on range scales and azimuth drums. The range and deflection must be further corrected for the position of both ships, their courses and speeds, at the instant of firing. This is done in the plotting room.

PLOTTING-ROOM CREW

The plotting room is located in the interior of the ship, usually below the protective deck. As a rule it is well forward. In some of the newer ships it is below the protective deck and practically under the conning tower and the fire-control station.

A switchboard in the plotting room gives telephone connections to every fire-control group on the ship, to spotters, turrets, guns, etc.

The principal duties of the plotting-room group are to plot on charts or on plotting boards, or to represent graphically with reference to the plane of fire, the course and speed of the target, and the rate of change of range and deflection, so that at any instant we can determine from reference to the charts the range and deflection at the instant, and also the continuous rate at which the range and deflection are changing at that particular time.

Separate plotting boards are provided; one for the determination of "range" and the other for "deflection."

The initial range and deflection and the course and speed of the enemy ship are plotted on the charts at the beginning of an engagement, the range and deflection being sent out to the sight-setters, and " set " reported to the fire-control station.

The spotter " **spots** " **the first salvo and gives a correction**, such as: Up 100, Right 2. This correction is immediately plotted on range and deflection boards, and the proper range and deflection for firing the next salvo is obtained, taking into consideration the course and speed of both firing and target ships. The new range and deflection is now sent to the sight-setters who correct their settings as ordered. " Set " is reported to fire-control and at the proper moment the firing buzzer and bell are sounded.

The spotter estimates the mean point of fall of this second salvo, and gives correction again to plotting room, and the procedure is repeated.

When a sufficient number of " spots " have been obtained and the range is increasing or decreasing at a rate that can be determined, a line or curve representing the " rate of change of range " is plotted. " **Deflection** " may be handled somewhat similarly. At any instant, knowing the approximate rate of speed of the enemy ship, you may determine his rate of speed made good on a course parallel to your own, as was done in computing initial range and deflection. This, with the bearing of the enemy, gives " deflection " at the instant.

In cases where a salvo hits or straddles the target and the spotter does not desire to change either range or deflection, he reports to plotting room " **No change.**" This is reported in turn to the fire-control officer by the plotting room.

RANGE CLOCKS: These are mechanical contrivances or clocks that are used in determining continuously ranges and deflections at which to set the sights in firing on an enemy ship. Certain data is placed on the clock, such as the rate of change of range and deflection, as soon as this is determined on the plotting boards. **The clock gives, at**

any instant for this rate of change, the range and deflection to set on the sight-scales. "Spot" corrections may be placed directly on the clocks.

These clocks are little used at the present time, and ships are no longer being fitted with them.

CONTROL OF BROADSIDE BATTERY

The latest idea in the control of broadside batteries is that the officer in charge of the broadside, or of a certain group of guns in the broadside, not only completely controls the fire of these guns, but is himself the spotter for them also. In his spotting position he has a "relay or group control switch." When this switch is in, he receives the fire-control signals and fires with other guns or groups on the ship. When he is not ready to fire, he throws out his switch and no signal sounds for his battery. He has with him a man with a range and deflection board, who plots all "spots" and sends out range and deflection to each gun after each salvo.

This system is largely used for torpedo-defense purposes.

SUB-FIRE-CONTROL STATIONS

Where a ship is equipped with both 12-inch and 8-inch guns in turrets, and also comparatively heavy caliber, 6- or 7-inch broadside guns, it is possible that all calibers might be desired to be brought into action together.

In such a case, we employ sub-fire-control stations.

A sub is provided for each caliber gun — they are called Sub-12; Sub-8; and Sub-7, depending on the caliber of the gun, and each sub-station has the particular duty of aiding in the control of the fire from its own guns.

Each sub sends out ranges and deflections to its own guns and reports "set" for that caliber to fire-control. In some cases, each sub has its own "deflection" and "rate of change of range" boards; also range clocks; and each works with the plotting room to control in the simplest way the entire firing of the ship.

CHAPTER XIX

SPOTTING

GENERAL DISCUSSION — VARIOUS METHODS

SPOTTING, as here used, refers to the judging of the point of fall of a projectile, with reference to a target or an enemy ship, in order to determine if a hit has been made, and, if not, to estimate what changes in range and deflection are necessary to make the next shot score a hit.

This is a subject which can and will be discussed only in the briefest and most general way, due to the desire of the Navy Department to keep the details of all methods employed and the results of all experiments conducted along these lines confined to confidential publications issued to officers of the Service.

The range-finder method of determining the range of an enemy vessel, in combination with other mechanically and electrically operated fire-control instruments, it is fully recognized, would be ideal for giving us at any instant the exact range, course, and speed of the enemy, were it not for the various and numerous "errors of gun-fire" with which we have to contend.

Certain of these errors of gun-fire are variable, and cannot be exactly determined, and for this reason we are compelled to resort to individual spotting, in combination with our range-finder and other instruments, in order to maintain an accurate control of the fire.

Spotters should be officers, highly and especially trained for this particular duty. Their importance cannot be overestimated.

For long range firing, 6000 yards or over, the spotters are stationed in the highest available part of the ship, usually in each " top " of the cage or fire-control masts. Large and comparatively powerful spotting telescopes are located in each " top," and the spotter stations himself at this.

When spotting for smaller caliber guns and sometimes under special conditions, a lower elevation is sometimes more advantageous and a special " **low spotting position** " is provided lower down in the cage mast.

After a shot has been fired, the spotter keeps the target or enemy ship closely in his field of view, and notes where the projectile lands with reference to the objective. By constant practice and with the aid of certain data he is able to judge in an almost inappreciably short time the change in range and deflection necessary to bring the next shot on the target.

There are two principal methods of spotting — the direct flight and the splash method.

The **DIRECT FLIGHT METHOD** is used for short ranges only, and requires the actual observance of the projectile itself as it falls in, or passes through, the plane of the target or enemy ship. As the projectile passes through the field of view of your telescope, which has been kept on the target continuously since the shot was fired, it appears as a comparatively small, blurred, and rapidly moving spot.

When the projectile can be spotted in this fashion, it is not difficult to tell if a hit was made, and if not, to give the necessary correction.

The other method of spotting, used for long ranges, is called the "**VERTICAL SPLASH METHOD.**" Spotting by this method requires a well-trained spotter. Briefly, the method is to observe the splash caused by the fall of the projectile, and from the position of the splash to judge the point in the water, beyond, in front, or to the right or left of the target, where the projectile fell. By projecting the line of vision from the spotter's position, through the base of the splash, and also, in the same straight line, through the vertical plane of the target (actual or extended), you can judge at what point the projectile,

either in the air or in the water, passed by or through the vertical plane of the target, by reference to a previously prepared "splash diagram." The corrections to the plotting room are given direct in yards of range and divisions of deflection.

Example — Up 200, Right 4.

SPLASH DIAGRAMS are used to assist the spotter. These represent graphically, on a target or ship drawn to a small scale, the area on the water within which the projectile would have to fall in order to hit the target (the danger space). This danger space or parallelogram drawn in on the vertical plane of the target **represents the space within which the projectile must appear to the spotter to have passed,** if it hit the target. Range and deflection lines are also drawn around the small scale target, giving the corrections necessary to bring the projectile on the target on the next shot. These diagrams should be drawn up before a target practice. Tables contain data to be used in connection with the diagrams.

The correction to be of value must be accurately and quickly determined, and this requires in a spotter a keen sense of judgment and a quick mind.

SPOTTING SALVOS: Modern battle practice, we know, is more a matter of salvos of shots than single shots. Our spotters, then, must be especially trained in spotting salvos.

There is always more or less dispersion or spreading of shots in salvo firing, due to the individual errors of guns and to personal errors of pointing. These can hardly be avoided.

In spotting salvos with a wide dispersion of fire the spotter has a difficult task. He must first determine the mean point of fall of all shots, and then determine the correction for the amount in range and deflection necessary to bring this mean point on the target on the next salvo. In salvo firing the shots should "straddle" the target, half over, and half in front.

Single-shot spotting, as compared with salvo spotting, is a very simple proposition.

SPOTTING BOARDS AND RANGES

These are merely arrangements to represent on a small scale, reduced in proportion, the problem of the spotter. By using a miniature target, and miniature splashes, it is possible to have a fairly realistic and certainly a very beneficial " spotting drill."

GENERAL

In any spotting it is better to spot " under " than " over." You are more likely to hit her somewhere with a low shot than with a high one.

Excessive or radical spotting corrections should be avoided. If a shell hits somewhere, even though not right on the " bull ", it is usually best to leave well enough alone and give " no correction."

CHAPTER XX

GUN DRILLS FOR BROADSIDE AND TURRET GUNS

POINTING, LOADING, AND FIRING DRILLS — STANDARD DRILLS FOR VARIOUS CALIBER BROADSIDE GUNS FOR THE PIECE IN ACTION

Gun drills have in view the primary object of working the crew of each gun up to such a state of efficiency and co-ordination, that during an engagement an accurate fire will be maintained by each gun, and the fire shall be as rapid as accuracy permits.

Practical results are sought. Each man in the gun crew should have a sound knowledge of the gun, the mount, and the drill; particularly he should know his own position and duties thoroughly. This is one of the prime purposes of the drill, and divisional officers are responsible for seeing that the proper instruction is given. Make every member of the gun crew understand **why** each detail of the drill is necessary. **Always keep in mind the ultimate object of it all — a rapid and accurate fire must be maintained.**

A battleship is built for the purpose of using her guns. During her whole career she may never have more than one opportunity to use these guns and then only for a few minutes. If, during this engagement, every gun crew, by virtue of its proper training, does its duty, maintaining a rapid and accurate fire, and, through preparation, overcomes all difficulties, then the cost of building and constructing the ship will be justified and our country will have been amply recompensed for its outlay in this respect.

COMMANDS USED IN GUN DRILLS

Preparatory to any drill at a gun, the crew should **fall in for muster** abreast their own gun and facing inboard. They should be in single file, tall men on the right, with the gun captain on right flank.

The above applies to broadside guns. In the case of turret guns, the crews either fall in on the deck outside the turret, or proceed directly to their stations in accordance with particular instructions.

Stations! Crew proceed on the jump to their gun, each man taking his own particular station. Each man looks over his own particular equipment as necessary and stands by for further commands. He must be ready to serve the piece.

Load! Crew loads the gun, ammunition being placed in bore and chamber, and piece made ready to fire on the command or signal.

Commence Firing! This command is often confused with the command "load." **The command "load" would be given every time the gun was loaded.** After "load" you stand by and fire on signal. **You would not load a second time without command. At "commence firing" you load and stand by for the firing signal. After firing, you reload without further command and continue firing and reloading without command until ammunition is exhausted or until command "cease firing."** Sometimes the command "load" is given for the initial loading. "Commence firing" is then given and causes the service of the piece to be continued until further command. **In case you are not firing on signal, but at will, the gun is loaded and fired at "commence firing" and this is continued until further command, the pointer firing whenever on the target.**

Silence! This command is given when, for any reason, it is necessary to temporarily stop the service of the gun. It may be given by the division officer or by any member of the crew noticing something requiring immediate attention. **When it is given, every member of the crew ceases**

all operations and stands in his tracks and awaits instructions. If a member of the crew calls "Silence!" he will point out, to the division officer or gun captain, what he has observed.

Carry On! After the command "Silence!" the defect having been remedied, this command is given, at which the crew resume the operation in which they were engaged when the command "Silence!" was given.

Cease Firing! The service of the gun is stopped and steps are taken so that the gun cannot be fired. The procedure will depend upon the type of gun, and for this purpose guns may be divided into two classes:

(*a*) B. L. R. guns (guns using powder in bags and separate primers in locks): Break the firing circuit at contact lug on breech-plug of gun and remove primer from lock.

(*b*) R. F. guns (guns using powder in brass case containing the primer):

I. If charge and projectile are separate, remove the powder case and close breech. (5-inch or 6-inch semi-fixed ammunition.)

II. If the charge and projectile are in same case, remove case, unloading the gun.

Unload! If the design of the gun will permit, the primer must be removed before the plug is opened. If this is done, the powder may be removed without fear of accident. **With R. F. guns the plug should be opened cautiously. When it is apparent that the service of the gun will not be resumed within a reasonable time, the powder which has been unloaded must be dumped into distilled water.**

Secure! At this command the ammunition will be returned to the magazine; spare parts returned to their places; unnecessary gear stowed away and guns and turrets secured. If the gun has been fired, as soon as possible after the firing has ceased, the gun should be thoroughly washed out, dried, and oiled. If practicable, this should be done while the gun is still hot.

PREPARATIONS FOR FIRING THE GUN

In proceeding to, and taking stations at a gun when it is to be actually fired, or when carrying out a drill to "Clear Ship for Action", a number of preparations must be made that are not made during an ordinary drill.

Each man of the gun crew brings with him to the gun, or provides, certain spare parts, material, or equipment, and each man also performs certain duties in preparing the gun to fire.

Each man of the crew must know in advance and be thoroughly drilled in his duty or duties in this emergency. He must know exactly where to go to get any necessary equipment so that he will secure it in the minimum time. He must know exactly how to proceed to prepare any part of the battery for action.

As an indication of what must be done, the following partial list is given, merely as a guide:

Examine training and elevating gear, including motors of turrets, to be sure they are in proper working order.

Test all fire-control apparatus.

Test fire extinguishing system.

Take out tompions from gun muzzles.

Provide sponges, buckets, gun tubs, and powder drowning tanks and fill with water.

Supply all spare parts and accessories.

Provide tools that might be necessary in case of breakdown.

Connect up electrical firing circuit and test it for grounds and faulty connections. Fire primers with both battery and motor-generator current. Try percussion firing.

Examine breech and firing mechanism parts.

Have spare gas-check pad ready.

Inspect and test gas-ejector system.

Examine powder bags and shell, if time permits.

Provide a loading tray and hand rammer.

Provide a first-aid outfit.

GUN POINTING AND SIGHT-SETTING DRILL

The GUN POINTER is probably as important a man as we have on the whole gun crew. Certainly, if the gun is not properly pointed or aimed at the target when the gun is fired, no amount of proficiency on the part of other members of the gun crew will be of any avail.

On a broadside gun, a pointer takes his position on a special stand provided and at the left side of the mount at the elevating-gear. He fires the gun, the firing-key being located in the handle of his elevating-wheel. His duty is to elevate and depress his gun muzzle as necessary to keep the horizontal wire of his telescope on the point of aim. He also coaches the trainer to keep the vertical wire on; and he fires on signal, when the cross-wires are steady on the point of aim.

The TRAINER occupies a position on the right of the mount similar to that occupied by the pointer on the left. His duty is to train the gun as necessary to keep the vertical wire of his telescope on the point of aim. Very little coaching by the pointer should be necessary; the two men should learn to work together by frequent practice.

The **SIGHT-SETTER** is stationed at the sight-setting mechanism on one side of the gun mount. **His duty is to set the sights as ordered.** The orders come to him in three different ways, to avoid any possibility of error: **by visual, figures for range and deflection showing up on a dial** mounted on top of the gun attached to the mount; **by telephone, the same data coming to him through receivers**, that he wears continuously, one over each ear; **and by voice tube**, called the sight-setter's voice tube, and at which another man, called the "sight-setter's talker", is stationed. The voice tube is particularly useful in case of the interruption of the telephone system, during an engagement, as an auxiliary. **The sight-setter's only duty is to set his sights, but everything depends on his ability to do this quickly, and absolutely without error.** In modern practice, in transmitting ranges, it is the custom to refer to the setting on the de-

flection scale or drum, merely as "scale." Thus, "range 5,050, scale 54", would mean to set the sight bar or dial at 5,050 and the deflection scale or drum at 54.

In a broadside gun crew, the three men referred to above — the pointer, trainer, and sight-setter — are designated as the **pointer group.**

IN A TURRET GUN CREW the duties of the pointer group are essentially the same as on the broadside guns. There are, however, several essential points of difference; **first, there is only one trainer in a turret and he occupies a position in the center of the turret between the two guns, and trains the whole turret right or left to keep the vertical wires on the point of aim** — neither gun has any motion by itself in train; **secondly, there is a pointer and sight-setter stationed at each gun, each gun being elevated individually.**

The duties of pointer and sight-setter are the same as on broadside guns. **The sight-setter of a turret gun is the second pointer,** to take post in the event of casualty to the first pointer; he must be especially trained with this end in view.

In a small gun, such as a 3- or 6-pounder, one man both elevates and trains by means of a shoulder-bar attached to the gun slide. A sight-setter, however, is in addition.

REQUIREMENTS FOR POINTERS AND TRAINERS are first of all that they be cool and non-excitable in disposition; also that they have plenty of nerve, good eyesight, and judgment. These characteristics will show up under the strain and excitement of firing heavy guns during a practice or engagement. The ability of a man to shoot straight with small arms is also a factor in the selection of pointers. Some pointers, especially when firing for the first time, get so excited, and are so afraid that the telescope will jump back and hurt them, that they will either not aim accurately, or they will jump away from the telescope or even away from the gun, after pressing the firing key; thus failing to keep the gun pointed during the firing interval, losing valuable time, and accomplishing poor results.

Requirements for a sight-setter are merely that he be cool, steady, reliable, and **not gun-shy.** He must be able to hear readily over a telephone or a voice tube. Remember that in turrets he is the second pointer.

DRILLING THE POINTER GROUP: The duties of the men of the pointer group are all closely allied. **They should therefore be drilled together at every opportunity.** In this way only will they learn each other's peculiarities and work as one coördinate unit.

Pointers and trainers must be taught to assume an easy, comfortable position at the gun — their hands must be properly placed; their eyes must be in the right position at their telescopes — **in short, they must be comfortable to get the best results.**

Various devices, mechanical and otherwise, are in use in the Service for the purpose of training gun pointers. The idea is always to assimilate actual firing conditions on a small scale, and thus give to pointers, trainers, and sight-setters practice in actually setting sights and keeping on a moving target. These devices include principally the **dotter,** the **Morris-tube,** the **check telescope,** and lastly **sub-caliber target practice.** The details of the manner of conducting the practice with these devices and their mechanism are kept secret by the Navy Department, and so cannot be described here.

Trainer and pointer should be impressed with the necessity of maintaining a continuous aim. During the **firing interval** or the period of time that elapses between the time the firing key is pressed and the time the projectile leaves the muzzle of the gun, a moving ship will travel far enough or roll sufficiently far to destroy the accuracy of the shot, **even though the cross-wires were exactly "on" when the firing key was pressed.** To offset this error, **keep the gun pointed continuously, especially after you press the firing-key.** An expert pointer will keep his cross-wires "on" while the gun is being loaded, and so be ready to fire the instant he receives the signal.

A spare set of pointers (trainer and pointer) should always

be in training for every gun, so that in the event of casualty to the first string men, you have others qualified to immediately take their places.

Sight-setters must be thoroughly familiar with the sights and understand the mechanism. They must be continually drilled at setting the sights; to approach the designated setting slowly and not to pass it and have to come back to it. They should practice daily, setting sights in accordance with ranges and deflections sent over the fire-control system. Until they are thoroughly proficient, the settings should be checked each time by gun captain or divisional officer.

LOADING DRILL

Loading drill for practice, that is, for the purpose of making each member of the loading crew familiar with the actual performance of loading ammunition into a gun, is ordinarily held on a **loading-machine.** So far as the breech end of the loading machine is concerned it is exactly similar to the breech of the gun itself, so that the machine has every advantage of the gun for loading purposes while not risking the possibility of marring the threads of the gun's screw-box or of developing lost motion in the breech mechanism by too frequent operation. A loading-machine is comparatively short and its muzzle end is fashioned in the manner of a tray, on to which the projectile and powder pass after being loaded into the gun.

Rapidity in loading and precision in every detail of the drill is of course the aim. This depends primarily on the rapidity with which each member of the gun crew performs his duty, and also the precision with which he performs his allotted portion of the drill. Lastly, **the gun crew must work together as a team, each member performing his duty in the service of the piece at exactly the proper time and in exactly the proper way, without interference with other members of the crew.**

Accuracy and thoroughness in every detail, even though it may require slightly more time, is an absolute requisite

to real rapidity of loading. Eagerness for excessive rapidity may result in serious delays caused by interference, confusion, and casualties that can be avoided only by precision in every movement. It must be remembered that these delays may more seriously interfere with the rapidity of fire than the deliberation necessary to avoid them.

The members of the crew should be carefully selected and they should be stationed in accordance with their particular qualifications for certain positions. For example: **the first loader and others who have the handling of a weighty projectile should be big, strong men. The powder men must be quick and agile, etc.**

The **gun captain** is, of course, the most important man on the whole gun crew and must be most carefully selected. As a rule, a gun captain should be a petty officer, but he may be a seaman, 1st class, if especially capable. Remember that, after the divisional officer, he is directly in command of the crew and in charge of the service of the gun during action. He should have a thorough practical knowledge of the gun, mount, and appurtenances, combined with executive ability, zeal, and general intelligence. Often, a good gun captain is the making of a whole gun's crew.

The following general rules governing the loading of guns are applicable to all calibers and types:

In firing a breech-loading rifle, or separate-ammunition gun, before a new load of ammunition is put into the bore, some designated member of the gun crew must sing out "bore clear." All guns of this type are fitted with gas-ejectors, the valves of which are operated as the breech-plug unlocks in opening, shooting a jet of compressed air down the bore. This compressed air blows out of the muzzle any inflammable gas remaining in the bore and any burning particles of powder, bags, etc., from the previous firing. It is the duty of the designated man to look into the bore after every shot, as soon as the plug is open, to be sure the gas and burning particles are gone (he must see daylight through the bore). If clear, he reports, "**Bore Clear**"

and the gun is again loaded. On the first shot "bore clear" must be reported to insure the "tompion" having been removed. The most available member of the crew is designated to report "bore clear."

The projectile must be carefully and fully seated in the gun. Otherwise the propelling gases will escape around the projectile before it attains its full velocity, and the range and accuracy of the fire will be materially reduced. It is absolutely required that all guns using separate ammunition have the projectile rammed home or seated with a rammer. A rammerman on the gun crew should insure this being done.

Watch the first shell shoved home in a clean gun. **If the gun is elevated (as by ship rolling), the shell is very apt to slip back and not be home when the gun is fired.** This is caused by oil on the compression slope, and it may occur after the powder charge is home and thus not be seen. Its effect is to reduce the velocity. **If the shell is persistent in slipping back, tie a little grommet of small twine around it just forward of the band. If a shell goes home properly, it emits a nonmistakable, clear, ringing sound.** If it gives a dull thud, it is not home.

In loading the powder bags into a gun, care must be taken that the ignition charge is always to the rear; otherwise a missfire or hangfire may result. The last charge to be loaded in should be just clear of the mushroom head. The red end must be next to the mushroom and primer.

Inserting a primer in a B. L. R. gun while the breech is open is not permitted, and the breech-plug must be closed and locked before the primer is inserted in the firing-lock. Exception is made in the case of guns where the wedge block, containing the firing-pin, is arranged to operate automatically by the functioning of the breech mechanism in such manner that the firing-pin cannot be brought opposite the primer until the plug is closed and locked. In the latter case the primer may be put in the lock while the breech is open. The Farçot 12-inch turret gun breech illustrates this type. **With locks that are operated by hand**

the plug must be closed and locked to within about one quarter of an inch of contact before the primer is inserted in the firing-lock. After the primer is inserted the plug should be completely locked. If it is desired to fire by percussion, and it is necessary to cock the lock and then fire it with a lanyard, the firing-lanyard must be hooked before the lock is cocked.

Every precaution must be taken against injury to the screw-box and gas-check seat. **To this end a loading tray must always be used except with fixed ammunition** and with B. L. R. guns, in which it has been demonstrated that the gun can be loaded without appreciable danger without a tray, — 5-inch is the only B. L. R. where a tray is not absolutely necessary.

Handling ammunition for rapid-fire guns. The shellmen should provide themselves with knives for cutting the lashings on the ammunition boxes and with waste for wiping off the cartridge-cases. Before target practice rapid-fire ammunition should be gotten up, thoroughly cleaned and tried in the gun, but if at any time the ammunition to be used has not been cleaned and wiped off, the above precautions are necessary. Care must be observed that no waste falls into the screw-box or gets in the bore. **Sometimes when handling rapid-fire ammunition, the projectile starts from its seat in the case. This should be looked for and shell reseated properly before attempting to load.**

When firing B. L. R. guns, the mushroom head must be wiped off with a wet sponge after each shot. If not, it gets so hot that in contact with the end of a powder bag it may ignite and cause the gun to fire prematurely.

When firing R. F. guns, while the plug is open the plugman should pass his hand over the face of the plug to assure himself that the firing-pin is housed properly. This is to guard against having a projecting firing-pin strike the primer as the plug swings shut, thus causing a premature explosion and possible disaster.

The prompt and regular supply of ammunition is essential to efficiency, therefore actual exercise in that feature is as

necessary as is exercise at the gun. Rapid loading, without a corresponding rapid ammunition supply, is without avail, and this supply includes every operation from taking the ammunition from the magazine and unboxing it to loading it in the gun. Especial attention should be given to providing for the disposition of cartridge boxes or powder tanks in such a manner as least to interfere with rapidity of serving the gun.

It is seldom necessary to clear the primer-vent, or path of primer flame through the plug. If it be found necessary, the priming wire should be used from the forward end of the plug, care being taken to avoid scoring the primer seat. After clearing the vent with the primer wire, take care to clean thoroughly the primer seat with the vent cleaner. In case of a blowback, the vent and primer seat should be examined for scoring and thoroughly cleaned. The vent reamer will not be used except under the direct supervision of an officer.

Fired primers. Keep primers that have been fired out of reach, otherwise somebody may try to use them again. This has not infrequently happened.

FIRING DRILL AT THE GUNS

FIRING DRILL includes all the steps already covered, such as pointing, sight-setting, and loading, and in addition, **the actual firing of the gun.**

Drill of this nature can be secured only at a target practice, but each member of the gun crew can be taught in advance just what special and additional preparations must be made before firing the gun.

As an indication of what these preparations must be in the case of a particular type of gun, **a battery officer's check list is given for a 5-Inch, 51-Caliber Breech-loading Rifle.** This is the type and size gun most frequently found in broadside batteries today.

Actually it should be necessary only to " check off " most of these items. **In time of war you may be called upon to**

fire at a very few moments' notice, and with this in view, all preparations possible should be continuously in effect.

Where you have advice that you will fire at a certain date and time, then you can make elaborate preparations for it, such as at target practice.

Paint safety circle on deck. — Only one charge of powder should be inside safety circle at a time. Crew outside safety circle, clear of gun's recoil at firing signal.

Examine trunnion knife-edges.

Adjust and measure trunnion clearance.

Clean and oil side of gun mount.

Examine keep screws of yoke sight mount. — To insure no lost motion in sight gear.

Paint mark on gun to indicate when gun fails to return to battery. — White strip on gun just aft of slide, when gun is "in battery."

Overhaul plug, examine gas-check pad and split rings.

Mount and test salvo-latch.

Bore-gauge. — Examine and test size of gun bore and condition of rifling.

Clean gas-ejector valve and test compressed-air supply.

Test air leads to gas-ejector.

Inspect tray for loading projectiles.

Examine powder.

Examine shells and tracers. — In case of target practice have heads of projectiles painted red.

Overhaul and adjust elevating-gear.

Overhaul and adjust training-gear.

Clean and adjust friction disk training-gear if fitted.

Secure and test voice tubes.

Remove any gear stowed overhead.

Adjust cross-wire illumination of both telescopes.

Examine eye buffers of telescopes.

Remove parallax from sights. — False reflection.

Clean sights.

Secure sights and telescope cross-wires firmly.

Bore-sight at expected firing-range (adjusting check telescope and sword scale).

Clean lenses with alcohol.

Soap lenses.

Overhaul firing-lock.

Clean and dry electric firing-contacts and firing-keys.

Recharge storage battery to give auxiliary source of current supply for electrical firing.

Test firing-circuit; voltage of motor-generator current.

Test firing-circuit; voltage of battery.

Inspect and test battle lanterns.

Inspect and test telephones.

Inspect and test buzzers.

Clean and test primers.

Fill recoil cylinders.

Remove tompions.

See all nuts in place and set up.

Remove ex-caliber guns and bands, if fitted.

Glue on reduced charge range scales. (In case of target practice and you are **to use reduced charge** ammunition.)

The following listed equipment and material will be provided by previously designated members of the gun crew.

Lens paper — to clean telescope lenses.

Gun tub and water — to wash gun parts, especially mushroom head, to keep cool, etc., during firing.

Sponge — for washing gun parts.

Bucket of drinking water — for crew.

Loading gloves — hands of loaders eventually become sore and irritated without gloves.

Bore-brush and swab. — To clean bore if necessary.

Whistle for battery-officer. — Needs this to attract attention above noise of firing.

Tools. — For emergency repairs.

Spare parts.

Hand lamps. — In case of failure of electric system.

Cotton for crew — to stuff in ears and protect ear drums from shock of firing.

Boric acid.

STANDARD GUN DRILLS FOR THE PIECE IN ACTION

5-INCH, 51-CALIBER B. L. R.

(Separate Ammunition)

Gun Crew

TITLE	STATION AND GENERAL DUTIES
Gun captain (Plugman)	At operating lever of breech — inserts primer.
Pointer	At elevating-wheel — keeps horizontal wire on. Fires gun.
Trainer	At training-wheel. Keeps vertical wire on.
Sight-setter	At sight mechanism. Sets sights.
Trayman	Operates loading tray. Operates gas-ejector. Stands to left and rear of breech.
Combination sponge and rammerman	Wipes mushroom after each shot. Operates combination sponge and rammer. Stands near plugman, and to his left.
First shellman	Loads shell in gun. Stands to left and rear of breech.
Second shellman	Keeps first shellman supplied with shell. In rear of first shellman.
First powderman	Loads powder in gun. Directly in rear of breech.
Second powderman	Keeps first powderman supplied with powder. In rear of first powderman.

Third powderman . . . At powder tanks. Removes powder bags from tanks and passes powder to second powderman.

GENERAL PREPARATIONS PRELIMINARY TO FIRING GUN. — Clear away the gun. See no obstructions to its operation.

Take out tompion.

Test: Training gear, elevating gear, breech mechanism, firing mechanism, percussion firing, gas ejector, sights, lights, fire-control system.

Communicate with magazine crews; test hoist signals and hoist. The gun cannot be regarded as fully ready until ammunition supply is ready.

Take off friction disk cover.

Provide: Combination sponge and rammer, hand sponge, loader's gloves, loading tray, gun and safety rules, tub of water, bucket of drinking water, first-aid kit, primer belt, primers, priming tools, large wrench, hand electric light, lens paper.

For general quarters drill, leave ammunition hoist cover down after testing hoist so that magazines are not exposed.

DETAILED TABULATION OF DUTIES OF EACH MEMBER OF THE GUN CREW IN LOADING AND FIRING A 5-INCH 51-CALIBER B. L. R.

GUN CAPTAIN. — On manning the gun reports when gun is "Ready."

Operates plug with right hand, standing close to gun, and inserts primer in lock with left hand. On opening plug, checks swing of plug with left hand to avoid jarring gun.

Watches salvo latch to know when gun has fired.

Notes return of gun to "battery position."

Watches firing-lock, when he closes plug, to see that primer is properly seated and firing-pin in place, making proper contact.

Each load, sees that shellman inspects to see bore clear before loading shell, and that powder man loads red end aft, and only after "Bore clear" has been announced.

When gun is loaded, sings out "Ready."

Carries primers in belt and has primer extractor hanging to belt.

POINTER. — Removes telescope sight caps; provides lens paper; cleans sights and check sight as necessary. **Examines firing circuit and sight lights, using both motor generator and battery.** Tests elevating-gear and **reports "Ready" to gun captain.**

Checks cross-wires with trainer.

Keeps cross-wires at all times on point of aim.

Fires gun.

TRAINER. — Turns on the compressed air, trains gun on designated arc, by arc of train pointer; takes off telescope sight cap; cleans sight as necessary; and examines cross-wire illumination. **Reports "Ready" to gun captain.**

SIGHT-SETTER. — Turns on sight lights; checks up zero of scale and sword arm.

Operates range and deflection scales as directed.

Sets sights, range first, repeating (in such tone and manner as not to be heard up voice tube) ranges and deflections for gun captain's check; and **reports "Set" to pointer when sights have been set.** Examines sights after each shot, resetting as necessary.

Repeats to the gun captain all orders.

If range or orders are not understood, sings out "Repeat" over voice tube (or telephone).

TRAYMAN. — **Stands to left and rear of breech.**

Holds tray, right hand on upper handle.

Inserts tray as soon as plug is opened, and removes it quickly after gun is loaded. Always keeps tray parallel to axis of bore.

Leaves air on while plug is open.

COMBINATION SPONGE AND RAMMERMAN. — Under normal conditions of firing, wipes off mushroom with wet hand sponge after each shot.

Stands to left of and close to plugman, left foot forward, facing breech.

As plug is opened, wipes off mushroom carefully, using

wet sponge held in left hand, and wipes out screw-box if necessary.

In any case of foul bore, dips combination sponge and rammer in gun tub, rams shell home, withdrawing sponge with spiral motion, which sponges chamber and mushroom.

FIRST SHELLMAN. — **In rear of breech, facing to right, as close to gun as safety will permit.**

Holds shell in the hands, point forward, directly in rear of and parallel to bore.

The shell is held with left hand midway between point and rotating band; and with right hand, palm against base, fingers downward.

Endeavors to seat shell firmly, avoiding striking tray, and makes way quickly for powderman.

In event of foul bore he sings out " Foul bore ", and, after loading shell, blocks powderman clear of gun.

SECOND SHELLMAN. — **Arranges shells on deck in rear of gun.**

Stands to rear and right of first shellman, directly in line of bore, right foot forward; and stands in position to enable him to look through bore as plug is opened. Picks up shell with both hands around the middle, so that first shellman may receive it in position to load.

As plug is opened, he examines bore, and if it is clear, he sings out " Bore clear." The gun must not be loaded until this report is made.

If bore is not clear, he sings out " **Foul bore.**"

FIRST POWDERMAN. — Stands directly in rear of breech, facing first shellman, and just to right of axis of bore produced. **Holds powder bag — red end in left hand, right hand near the middle — parallel to axis of bore,** becketed end directly in rear of plug in position to be just clear of lock when gun recoils. As shell is loaded powderman shifts weight of body to right leg carrying powder bag forward, **inserts bag closely following shell, and pushes with left fist, ramming the shell fully home. He must be careful to seat the shell.**

SECOND POWDERMAN. — Arranges powder tanks, standing them upright on deck to rear and right of gun, clear of all members of crew.

Stands to left of first powderman.

As powder is loaded in gun, he takes another charge from the tank, and gives it — red end to rear — to the first powderman.

THIRD POWDERMAN. — If this man is necessary by reason of inconvenient location of the ammunition supply hatch, he, rather than the second powderman, removes the charges from the tanks and passes them to second powderman, one at a time.

COMMANDS.

STATIONS! — Crew proceeds to gun and takes stations. Gun captain reports "**Ready**" when all preparations for loading have been completed.

LOAD! — Command given as soon as gun captain reports ready. Gun is loaded as has been described, and gun is held ready to fire on signal; gun captain again reporting "ready" when loading is completed and the gun is ready to fire.

COMMENCE FIRING!—Command given as soon as gun is loaded and ready to fire. Pointer fires on signal. Gun is reloaded without further command and fired again on next signal, and so on continuously.

CEASE FIRING!—The service of the gun is stopped. If the gun is loaded, gun captain rotates plug far enough to break the firing circuit, **then withdraws primer and examines it to see if it has fired.**

UNLOAD!—To unload, remove primer if it has not already been withdrawn and examine it to see that it has not been fired. If not, open breech, remove powder charge and shell. Return powder charge to tank and carefully mark tank for identification. If firing is not resumed, this charge, upon gunnery officer's orders, will be subsequently dumped into distilled water. If the primer has fired, the gun will be treated as in the case of a hangfire.

SECURE! — The members of the crew, under the supervision of the gun captain, return everything that has been provided and secure the gun. If the gun has actually been fired, the crew assist the gunner's mate in washing out and oiling the bore. The crew fall in for muster.

5-INCH, 51-CALIBER RAPID-FIRE GUN

(Semi-fixed Ammunition)

Gun Crew

TITLE	STATIONS AND GENERAL DUTIES
Plugman (gun captain)	At operating lever
Pointer	At elevating wheel
Trainer	At training wheel
Sight-setter	At sight mechanism
First shellman	Left and rear of breech
Second shellman	To pass shell to first shellman
First powderman	Left and rear of breech
Second powderman	Right and rear of breech
Third powderman	Pass powder to first powderman

The drill at this gun is essentially the same as at the 5-Inch, 51-Caliber B. L. R. just described.

In general the duties of the members of the gun crew are similar to those listed for the B. L. R.

The essential points of difference are: first, the primer is seated in the cartridge-case and the firing-pin is housed in the breech-plug; second, semi-fixed ammunition is used, consisting of a powder charge in a brass case and a separate projectile so that neither a rammerman nor a trayman is necessary.

COMMANDS.

STATIONS! — The gun crew go to their stations preparatory to loading and firing the gun.

LOAD! — (The gun having been fired.) This is assumed in order to show the manner of **continuing the service of the piece.**

Pointer and trainer keep gun on target.

Sight-setter sets sight as ordered.

Plugman opens breech; **feels face of plug to see firing-pin housed.**

First Shellman puts in shell and attempts to seat it by giving it a quick shove; gets another shell from second shellman.

First Powderman puts in brass case and gets another one from third powderman.

Plugman closes breech and **calls out "Ready!"**

Second Powderman stands by to **catch empty case when gun is fired.**

Other shellmen and powdermen provide and supply shell and powder to first shellman and first powderman.

COMMENCE FIRING! — This command may be given either before or after the gun is loaded. If given before, the gun will be loaded at once. The firing and service of the gun are started, the pointer firing on the firing signal, or when on the target, depending upon the nature of the practice being held. The gun is reloaded as soon as fired, and firing continues until the ammunition is exhausted, or until the command "Cease Firing!"

CEASE FIRING! — The service of the gun is stopped. If the gun is loaded, the plugman opens breech; second powderman withdraws brass case.

UNLOAD! — This command may be given after the command "Cease Firing!" in which case only the shell has to be removed, or it may be given while the gun is loaded, and before the command "Commence Firing!" In the latter case —

Plugman opens breech.

Second Powderman withdraws brass case.

First Shellman withdraws shell. (It may be necessary to ram the shell out to the rear from the muzzle.)

SECURE! — Secure the piece as usual.

3-INCH, 50-CALIBER RAPID-FIRE GUN — 4-INCH, 50-CALIBER RAPID-FIRE GUN

(Fixed Ammunition)

The drills for the above guns are identical.

Gun Crew

Title	Station
Plugman (gun captain)	At operating lever
Pointer	At elevating wheel
Trainer	At training wheel
Sight-setter	At sight mechanism
First shellman	Left and rear of breech
Second shellman **Third shellman**	Rear of first shellman
Fourth shellman	Right and rear of breech

More shellmen may be required if the ammunition supply is difficult.

COMMANDS.

STATIONS ! — At this command the crew go to their stations preparatory to loading and firing the gun.

LOAD ! — (The gun having been fired.)

Pointer and trainer keep gun on target.

Sight-setter sets sights as ordered over fire-control system.

Plugman opens breech and feels face of plug to see if firing-pin is housed.

First Shellman inserts and shoves home the cartridge-case.

Plugman closes breech and calls out "**Ready** !"

Second and third Shellmen provide ammunition to first shellman.

Fourth Shellman stands by to remove empty case after gun is fired.

COMMENCE FIRING ! — This command may be given either before or after the gun is loaded. If it is given before, the gun will be loaded at once. The firing and service of the gun are started, the pointer firing on the firing signal, or when on the target, depending upon the nature of the prac-

tice being conducted. The gun is reloaded as soon as fired, and firing continues until the ammunition is exhausted or until the command "Cease Firing!"

CEASE FIRING! — The service of the gun is stopped. If the gun is loaded, the plugman opens breech. First shellman withdraws loaded cartridge-case.

UNLOAD! — This command will be given only after the gun is loaded and before the command "Commence Firing!" Procedure is the same as at "Cease Firing!"

SECURE! — The members of the crew, under the supervision of the gun captain, return everything that has been provided and secure the gun. If the gun has actually been fired, the crew assist the gunner's mate in washing out and oiling the bore. The crew fall in for muster.

The drill for all **rapid fire-guns using fixed ammunition** is essentially the same as outlined above, not including of course "pounder" or "semi-automatic" guns.

3- AND 6-POUNDER SEMI-AUTOMATIC GUNS

Gun Crew

TITLE	STATION
First pointer	Shoulder piece
Second pointer (sight-setter)	At sight
Loader (acting gun captain)	At operating lever
Shellman	Right rear of breech
Shellman (second)	Right rear of breech

The drill for all three types of semi-automatic guns in use in the Service today, Vickers-Maxim, Driggs-Seabury, and Hotchkiss, are practically the same. The only change necessary is to have the loader on the side opposite the sight and the second pointer on the same side as the sight.

COMMANDS.

CAST LOOSE AND PROVIDE!

First pointer removes gun cover; takes out the tompion; unclamps pivot-and-cradle clamps; assisted by loader; then reclamps them; tests breech mechanism; examines

bore; seeing it clear; sees gun and mount in working order; then takes station at shoulder stock.

Second pointer takes off the sight covers, or ships sight and sees all in adjustment and working order.

Loader commands; provides and examines the reserve box; sees in place bristle sponge; assists first pointer in unclamping and reclamping the gun; takes position to the right or left of the breech, facing the rear, in position to receive cartridges from shellmen; when all is ready reports to division officer.

Shellmen bring ammunition from hatch; provide bucket of fresh water, clean hand swab; take station in rear of loader and alongside ammunition, ready to rapidly pass cartridges to loader, being careful to see that all cartridges are wiped clean with oily waste.

LOAD!

First pointer keeps stock to shoulder, having previously taken easy and steady position at gun, feet well apart, and keeps gun continuously trained on target.

Second pointer sets sight.

Loader opens the breech smartly, if not already open; inserts cartridge and smartly shoves it home with the heel of the right hand until the rim of the cartridge head takes against the extractor, thus automatically closing the breech.

Efficient loading will require much drill and practice to acquire the necessary expertness. The loader must be trained to center the cartridge rapidly and shove home smartly with closed fingers of right hand pressing firmly against head of cartridge, palm of hand toward muzzle of gun, following the cartridge home with the hand.

With the ammunition well cleaned, and careful attention paid to the above details of shoving cartridge home, there should be no failure of breech to close. **If the breech block fails to close, withdraw the cartridge, examine for dirt, burrs, or defective ammunition.** If nothing is found, make a second trial, shoving home as smartly as possible.

Never, under any circumstances, use anything but the hand in loading.

Shellmen pass cartridges to loader, and keep empty cases clear of the gun; clean cartridges when necessary.

COMMENCE FIRING!

First pointer fires when on the target.

Second pointer sets sight.

Loader continues loading.

Shellmen pass cartridges to loader. If conditions require the absence of both shellmen to obtain fresh supply of ammunition, when supply is about exhausted, shellmen will place the box near enough to the loader to enable him to handle the shell without leaving his position at the gun. The shellmen go for fresh supply of ammunition..

Premature firing with semi-automatic guns is liable to occur with inexperienced pointers, who, through nervousness, retain a pressure on the trigger after firing.

CEASE FIRING OR UNLOAD!

First pointer discontinues the firing, steadies gun until clamped, then stands clear.

Loader slowly opens breech; when cartridge has been removed, closes breech by pressing on extractor nibs with the rammer; clamps gun in elevation and train.

First pointer snaps the lock.

Shellman removes cartridge, wipes clean, and replaces it in the ammunition box.

SECURE!

Crew return what they provide and secure what they cast loose; assist to clean the bore, breech mechanism, etc., and then form for muster. If the gun has not been fired, they form for muster immediately after they have returned what they provided.

The drill at a 3- or 6-pounder that is not semi-automatic in its action, but merely a rapid-fire gun, is essentially similar to what has been described.

The essential points of difference are: first, that an additional member of the gun crew, a plugman, is necessary — he takes his station at the operating lever, the loader in this case being to the rear and right of breech or on side

opposite the sight; secondly, the plug must be operated, the breech-block being dropped, after each shot, the same as any other rapid-fire gun.

1-pounder drills also are essentially the same as has been described. A 1-pounder employs a slightly smaller crew.

6-INCH, 50-CALIBER B. L. R.

(Separate Ammunition)

Gun Crew

TITLE	STATION
Plugman and gun captain	At operating lever
Pointer	At elevating wheel
Trainer	At training wheel
Sight-setter	At sight mechanism
Trayman	Left and rear of breech
Rammerman	Rear of breech
First shellman	Left and rear of breech
Second shellman	Rear of first shellman
Third shellman	At ammunition supply
First powderman	Right and rear of breech
Second powderman	Rear of first powderman
Third powderman	At ammunition supply

NOTE: More or less shellmen and powdermen may be required, depending upon the facility with which ammunition can be supplied from the hoist. Some officers prefer an additional man as primerman. This leaves the plugman free to wipe off the mushroom head and watch the loading.

COMMANDS.

STATIONS! — The members of the crew go to their stations preparatory to loading and firing the gun.

LOAD ! — (The gun having been fired.)

Pointer and trainer keep gun on target.

Sight-setter sets sights as ordered.

Plugman opens breech, puts in new primer, wipes off mushroom head.

Trayman inserts tray and closes air valve.

Rammerman calls " Bore clear ! " rams shell home as soon as it is in the bore, making sure to seat the shell, withdraws rammer quickly.

First shellman, as soon as bore is clear, throws in shell and gets another from second shellman.

First powderman loads in powder as soon as rammer is withdrawn, and gets new charge from second powderman.

Trayman withdraws tray.

Plugman closes breech and calls out " **Ready!** "

Other shellmen and powdermen supply shell and powder to first shellman and first powderman.

COMMENCE FIRING ! — This order may be given either before or after the gun is loaded. If it is given before, the gun will be loaded at once. The firing and service of the gun are started, the pointer firing when the firing signal is given, or when he is on the target, depending upon the kind of practice being held. **The gun is reloaded as soon as fired, and firing continues until the ammunition is exhausted, or until the command " Cease Firing! "**

The remainder of the drill is carried out identically in the manner described in detail for a 5-inch, 51-caliber B. L. R.

Six-inch guns of this type are usually found in the broadside batteries of battleships of the pre-dreadnought type.

7-INCH, 45-CALIBER B. L. R.

Guns of this type are found on only one class of ships in our service — battleships of the pre-dreadnought type and of the class of the U. S. S. *Connecticut, New Hampshire, Vermont,* etc.

The drill is somewhat distinctive, having one unique feature: a loading tray having four handles and operated by four men, two on each side. The reason for this is that the weight of the projectile is entirely too much for one man to handle. **In loading, projectile and powder charge are**

placed on the tray while it is on the deck. At " bore clear ", all four men together swing tray up to breech, smartly, so as to start shell forward. Rammerman rams projectile and charge together into the gun.

In other respects the drill is the same as at the 6-inch B. L. R. just previously described.

Gun Crew

Title	Station
Gun captain (if extra man)	Where he can best direct crew
Plugman	At operating lever
Pointer	At elevating wheel
Trainer	At training wheel
Sight-setter	At sight mechanism
First trayman	At right front handle of tray
Second trayman	At left front handle of tray
Third trayman	At right rear handle of tray
Fourth trayman	At left rear handle of tray
First rammerman	To rear and right of tray
Second rammerman	To rear and left of tray
First shellman	To left of tray
Second shellman **Third shellman**	Provide shell to 1st shellman
First powderman **Second powderman**	To right of tray
Third powderman **Fourth powderman**	Provide powder from hoist

AT COMMAND " LOAD ! "

Pointer and Trainer keep gun on target.

Sight-setter keeps sight set.

Plugman opens breech and inserts new primer; wipes off mushroom head.

Fourth Trayman calls " Bore clear ! "

All traymen at signal from first trayman lift tray and swing it forward into breech smartly to start shell. Withdraw tray when charge is clear of it.

Second Trayman closes air valve.

Rammerman rams charge (shell and powder) home, and withdraws rammer. Places end of rammer against rear powder bag on tray on deck as soon as it has been re-loaded.

Plugman closes breech and calls out " Ready ! "

First Shellman places shell on forward end of tray as soon as it is in position after being withdrawn.

First and second Powdermen place forward and after sections of powder on tray in rear of shell for next load.

Other shellmen and powdermen provide shell and powder in handy position.

TURRET GUN DRILLS

The following general stations for turret drills are given. They will apply to every case. No detailed turret drill can be used as a guide owing to the considerable number of different types of turrets in use on ships in the Service at this date:

Turret officer. — The station of the turret officer is habitually in the turret booth. If the turret is not fitted with a booth, as in the 8-inch turret, he must be where he can best exercise his command of the turret.

Junior officers. — If there is only one junior officer, his station is usually in charge of the ammunition crew. If there are two or more, one of them should be in the turret, as they may, at any time, be called upon to take command of it.

Turret captain. — The turret captain is stationed at the discretion of the turret officer. It is considered best to put him in direct command of one gun, and a junior officer (if available) in direct command of the other, the turret officer supervising both.

Gunner's mates. — Every turret has permanently assigned to it one or more gunner's mates. **These cannot be used as members of the gun's crews,** but should be stationed where they will be available in case of breakdown of any part of the mechanism.

Turret electricians. — Every turret should have an electrician permanently detailed for duty in the turret, and whose battle station is in the turret. His duties are to keep the electrical installation in good working order, and his battle station is wherever he can best look out for fuses and circuit breakers.

Gun captain. — Each gun of a turret should have a gun captain, qualified or acting. He should be selected with great care, due weight being given to his ability to handle men, knowledge of the gun and mount, alertness, keenness, and judgment. He may have no additional duties, or may occupy a station of the loading crew. In any case he should be in a position to observe and direct the work of the crew.

Pointers and sight-setters. — Every gun in a turret must have at least two pointers, the sight-setter being the second pointer. There is now a growing tendency in the Service to have two sight-setters, one for deflection and the other for range, one wearing the telephone and the other the voice tube. This is recommended if the extra men are available and the construction of the sights and turret permit.

Trainer and sight-setter. — Every turret requires a trainer and a trainer's sight-setter. These are usually called first and second trainers. Their stations are, respectively, at the training wheel and the trainer's sight mechanism, and their respective duties are to keep the turret trained on the target, and to keep the sight set according to the orders through the fire-control system.

Messengers. — It is well to have a messenger in the turret and one in the handling room. The one in the turret should be in the booth with the turret officer, and the one in the handling room should be at the voice tube leading to the turret.

In charge of handling room. — When there is no junior officer in charge of the handling room, a petty officer, thoroughly familiar with the drill, should be placed in charge and held accountable.

DESIGNATION OF MEMBERS OF TURRET GUN CREWS AND THEIR DUTIES IN BRIEF

Plugman. — One who operates the plug.

Hoistman. — One who operates a hoist (in two-stage turrets, preceded by word **upper** or **lower**).

Rammerman. — One who operates a rammer, either hand or power.

Trayman. — One whose primary duty is to put in and take out the loading tray.

Shellman. — One whose primary duty is to handle shell.

(*a*) Those in turret numbered 1st, 2d, 3d, etc.

(*b*) Those in shellroom, those in handling room — no numbers necessary.

Powderman. — One whose primary duty is to handle powder.

(*a*) Those in turret numbered 1st, 2d, 3d, etc.

(*b*) Those on platforms to pass up powder — **platform powdermen.**

(*c*) Those in handling room — **handling room powdermen.**

(*d*) Those in magazine — **magazine powdermen.**

Signalman. — One whose primary duty is to operate signals or indicators between turret and handling room.

Carman. — In power-loading turrets there are sometimes required one or more men who open and close doors on the car (when in rear of the gun), or otherwise trip the powder from the inside of the car to the loading tray. While these men may be called powdermen, it is sometimes better to call them **carmen.** This title should not be used for those turrets in which powder is put on to the tray by actually picking it up and placing it there, but only for those in which the operation is done without actually handling the powder.

The drills are carried out along the same general lines as the drill for a B. L. R. broadside gun.

In every turret, the drill will, of course, vary in details to accommodate the type and construction.

Usually powder is passed up by hand, by powdermen on stages leading to the turret proper from the handling room. The charges are taken from the tanks in the handling room so as not to clutter up the turret with them.

Projectiles always come up in cars, actuated by electric hoists.

In conducting a turret drill it is always good practice to time the loading of the crew of each gun. This stimulates competition between the crews, lends interest to the work, and has general good results.

CHAPTER XXI

THE BATTERY IN ACTION

CASUALTIES TO MATERIAL AND REMEDIES TO PERMIT CONTINUATION OF FIRE — MISSFIRES AND HANGFIRES — SAFETY ORDERS GOVERNING USE OF THE BATTERY

THE various guns of the battery are served and fired as has already been described in detail in connection with the discussion on "Gun Drills."

There are bound to occur, at some time or other when a gun is being fired, certain difficulties or contingencies, such as the failure of certain parts of a mechanism, that can hardly be anticipated.

Many of these "casualties to material" can be remedied quickly by a gun crew well drilled to meet such contingencies. Others will have to be solved by the ingenuity and alertness of the gun crew and officer.

The following list of "casualties to material" represents those most likely to occur, and the remedies for them as listed should serve not only to point out the remedy for particular casualties, but also to suggest means to correct others not listed. The list is as complete as it was possible to compile from various sources — it does not, however, by any means, include all that are possible to occur.

THIS LIST REPRESENTS THOSE CASUALTIES MOST LIKELY TO OCCUR ON A BROADSIDE GUN, OF THE B. L. R. TYPE (SEPARATE AMMUNITION), AND OF MEDIUM CALIBER — 5, 6, OR 7-INCH.

Failure of gun to return "to battery." — In case the gun fails to return to battery, cease firing; do not load the gun; depress gun as far as possible. Pointer elevates and de-

presses quickly with jerky motion of elevating wheel; trainer trains right and left in same manner; gun crew endeavors to raise gun and jar it back into battery. **Marks should be fixed or painted on gun to indicate to gun captain whether or not gun has fully returned to battery.**

Foul bore. — (Gun bore not thoroughly cleared of gases or burning particles by gas-ejector.) In any case of foul bore, anyone noting same shall sing out "Foul bore." First powderman instantly jumps away from the breech of the gun with exposed powder bag. Second powderman, assisted by other members of gun crew, get powder tanks clear. First shellman loads shell in gun, and blocks first powderman. (Shell blocks bore and cannot be affected.) Combination sponge-and-rammerman dips sponge in water, rams shell, and swabs out chamber.

Telescope cross-wires out of adjustment. — During the firing, should the cross-wires of either sight be jarred out of alignment report it to the gun captain at once. This will be recognized, probably, at once; but if not, it may be detected by the excessive coaching of the pointer and difficulty he has in getting and keeping the trainer on. The gun captain at once goes to the check sight and checks them up. **If one sight is practically on with the check, and the other off, then the man who is "on" does the firing and coaches the other as best he can.** If he be the trainer, he fires by singing out "Fire" when his cross-wires are on the target, and the pointer presses the firing key. The check telescope is always bore-sighted with the other.

Blurring of telescope sights. — Lens paper is kept close at hand by both pointer and trainer for use in case sights become blurred. Gun captains should caution them to wipe off their sights whenever they appear to be having any trouble of any kind with them, or in seeing the target clearly.

Broken powder bag. — Stop firing until all loose grains of powder have been picked up from around gun and out of screw-box, and dumped into tub of water. **Wash out screw-box with water and sponge to insure the removal of all black powder grains.**

Broken air line. — (Gas-ejector supply.) Trayman keeps end of air hose from whipping around. Second powderman immediately turns off air valve under gun. Combination sponge-and-rammerman must then sponge out powder chamber after each shot. Send for gunner's mate to repair air line.

Primer jamming in firing lock (Magazine firing-lock).

(1) **Feed jams**: Where the primer is not fed through the primer guide. **Procedure**: Look at the lock, see first if the hammer has fallen all the way; if it has not, the wedge will be about one-tenth of an inch from closed. Pull the hammer back (not too far if using two primers) and release it. This should force primer through guide.

(2) **Wedge jam**: Where primer has fed through the primer guide, but jams in primer seat and prevents wedge from closing. This may occur following a feed jam. **Procedure**: In this case, primer is clear of primer guide — hence, eject primer with considerable force, and reprime.

(3) **Repeated feed jam**: Where primer refuses to feed through the guide, even after the hammer has been dropped on the primer several times. **Procedure**: This case is unusual, and the only remedy is to take down the lock and clear the jammed primer.

All members of the loading crew should be instructed to recognize instantly these three kinds of primer jams.

The trayman and first shellman are in particularly advantageous positions to recognize the nature of the jam, and should be given special training to this end that they may call out readily the type of jam, for the information of the plugman.

Plug will not open or close—Look for marred threads on plug or in screw-box. Remove with half-round file. If threads are not cause of trouble, examine mechanism, and send for gunner's mate with tools and spare parts.

Firing circuit cut or jarred loose—If only jarred loose, replace and tighten up. **If cut**, send for electrician and in meantime fire by percussion.

Gas-ejector fails—Powder chamber must be sponged out

after each shot. Watch carefully for "foul bore" and "flare-backs."

Electric lights fail — Use oil hand lamps or portable battery flash-lights provided in advance.

Burning fragments on mushroom head or in powder chamber — Sponge off thoroughly as soon as breech is opened, with sponge and water from gun-tub.

Ammunition hoist disabled — Send for gunner's mate. Secure ammunition from nearest hatch or supply, until repairs are effected.

Fire in turret or vicinity of broadside gun — Remove all powder from vicinity of fire. Turn hose on fire (should be led out on deck). Stop sending up ammunition in vicinity until fire is out. Continue service of gun if possible.

Powder bag comes wrong end toward breech — Any member of crew noticing it, calls "**silence.**" If noticed before gun is fired, unload and load again properly. If not noticed and you press firing-key, you will probably have a hangfire to contend with.

Primer vent choked — Clear from mushroom end of plug with small wire provided for the purpose.

Shell does not seat properly — If it will not ram home under ordinary force, unload it and lay the projectile aside as defective.

Firing signal system fails — If only for your gun, send for electrician. Fire as near as possible with other guns. If ship's entire system fails, you will either get signal by telephone or will fire at will.

Broken rammer — Send to ordnance storeroom for new. In meantime endeavor to seat shell by throwing home, and "following" with powder bag.

Circuit breaker blows (Ammunition hoist circuit). Send for electrician; while repairs are under way secure ammunition from nearest supply.

Primer blowback, fusing metal of primer case: Examine primer seat; is probably loose from too frequent reaming. Use such spare parts as necessary to have firing-lock function properly on next shot.

Friction disks of training-gear slipping — If friction disks slip, allowing breech of gun to drop toward deck, loosen disks, raise breech to normal position by man power, and set up on disks again.

Other casualties — Other casualties, such as jammed plug, etc., will be remedied as quickly as possible, sending for a gunner's mate for assistance or spare parts.

Hangfire — If the gun fails to fire, and the extracted primer shows that the primer has fired, the condition of "hangfire" exists.

Missfires — Most missfires are due to the failure of the pointer to make proper contact with the firing-key. **The pointer must always press down hard on the firing-key, and hold it down for an appreciable interval.**

If the gun fails to fire, the pointer sings out "Missfire." The gun captain immediately cocks piece, holding back cocking arm with left hand, and sings out "Ready percussion." When the pointer is again ready to fire, he sings out "Fire", at which the gun captain releases cocking arm and jerks his arm out of the way.

(*a*) If gun fires, pointer must shift transfer switch to battery before firing next shot by electricity.

(*b*) If gun fails to fire by percussion, gun captain sings out, **"Missfire; shift primer." He extracts and examines primer; if it has fired,** the procedure for "hangfire" shall be followed. If the primer has not fired, a new primer is inserted, and when it is seated, the gun captain sings out, "Ready." While gun captain is shifting primer, pointer shifts transfer switch back to motor generator and endeavors to fire next shot electrically. If the gun again fails to fire after transfer switch has been shifted, continue the firing by percussion until opportunity **offers for repairing firing** circuit.

The following list represents casualties that, in addition to most of the foregoing, are likely to occur in rapid-fire guns using fixed or semi-fixed ammunition.

Jammed cartridge-case — Usually due to dirt or foreign matter remaining in the gun chamber from the previous

shot. Apply more strength to operating-lever, fitting an extension to it to get more leverage if necessary. Examine extractor.

Bent firing-pin — Causes not only missfires, but, by jamming in a forward position, may cause premature firing of primer and gun, by striking percussion cap of combination primer. Straighten pin and watch carefully. **Gun captain passes fingers over face of plug each time he opens breech to insure the firing-pin being housed.**

DRILLING THE GUN CREW IN OVERCOMING CASUALTIES TO MATERIAL

It is absolutely necessary that the crew be drilled at casualty drills. No matter how efficient the crew may be at loading, sooner or later a breakdown or interruption may occur. Then it is of vital importance that the crew be prepared to remedy the defect in the shortest possible time, in order that the services of the gun may not be lost to the ship. **To this end officers must not only explain to the crews what to do in case of any probable casualty, but must " actually drill " them in doing it. To neglect this is fatal.**

CASUALTIES TO PERSONNEL

In case of injury to any member or members of the crew, the gun crew must be drilled so that those remaining will continue to serve the gun. It is to be expected that, in this case, the service will not be as efficient as before the casualty; but it must be distinctly understood that **no gun is to be abandoned, even by the last remaining man, as long as it can be loaded and fired. For the above reason every man in a well-trained gun crew should be familiar with the duties of every other station, and should be prepared to perform them without hesitation.**

Removal of personnel casualties: The removal of casualties is a matter to be specially provided for in each ship. It is the duty of the gun crew to continue the service of the gun

and to overcome every obstacle which interferes therewith. The gun crew will therefore not cease their operation of loading, but two men nearest to the wounded man should, without orders, place him in any convenient position clear of the working of the gun, whence he will be given first-aid treatment, then removed, as elsewhere specified. **The operations of loading or firing will never be discontinued for the purpose of removing personnel casualties, except in cases of absolute necessity.**

MISSFIRES AND HANGFIRES

A MISSFIRE occurs when the pointer attempts to fire the gun and the charge fails to explode.

A HANGFIRE occurs when there is an appreciable interval between the attempt to fire and the explosion of the charge. A hangfire can occur only after an apparent missfire.

MISSFIRES can be divided into two classes: primer missfires, and powder-charge missfires.

Primer missfires occur when the primer fails to explode. **The most frequent causes are listed.**

Electric firing:

- Failure of pointer to close contact through firing-key.
- Poor or broken connections; not carefully tested before firing, or jarred out, or cut during firing.
- Ground on the circuit.
- Dirt or grease on primer or contact lugs.
- Insufficient voltage — battery run down.
- Defective primer, — rare.

Percussion firing:

- Broken firing-pin.
- Weak mainspring.
- Dirt under firing-pin shoulder.
- Firing-pin not directly over cap of the primer.
- Defective primer, — rare.

Powder-charge missfires occur when the primer explodes but the powder-charge fails to explode. **The most frequent causes are:**

Powder loaded in wrong, — ignition end of charge forward (red end not toward primer).
Powder shoved in too far, — exceedingly rare.
Powder wet.

PROCEDURE IN DETAIL TO COVER ALL CASES

(Extract from Ship and Gun Drills, U. S. Navy)

Procedure for B. L. R. guns (guns using combination primers in locks that permit of removing the primer without opening the breech)

- **Missfires electrically** (battery and motor generator).
  - **Cock firing lock and try percussion. If it**
    - **Fires** — Examine connections; try electric on next shot. If it
      - **Fires** — Connections are O. K. Continue electric firing.
      - **Miss-fires** — Use percussion firing thereafter.
    - **Miss-Fires** — Extract primer and see if it has exploded. Insert new primer and try it electrically. If it
      - **Fires** — Connections are O. K. Continue electric firing.
      - **Miss-fires** — Try percussion. If primers are found to have exploded, continue to fire primers as long as there is a reasonable chance of igniting the charge. If the primers have not exploded (which will rarely be the case), keep trying new ones until one explodes. If all attempts fail to explode the charge but you have succeeded in exploding the primers, **WAIT 30 MINUTES BEFORE OPENING THE BREECH. In war times you can open at the discretion of the Commanding Officer.**

Procedure for R. F. guns using combination primers in cartridge cases

- **Missfires electrically.** (battery and motor generator). Cock firing lock and try percussion. If it
  - **Fires** — Examine connections; try electric on next shot. If it
    - **Fires** — Connections O. K. Continue firing electric.
    - **Missfires** — Use percussion firing thereafter.
  - **Missfires** — Cock firing lock and try again by percussion. If it
    - **Fires** — Try electric next shot.
    - **Missfires** — Try several times both by percussion and electricity. If it fails to fire, **WAIT 30 MINUTES BEFORE OPENING BREECH! In war times captain uses discretion.**

Procedure for R. F. guns using percussion (only) primers in cartridge cases

- **Missfires** — Recock and keep trying until it fires or until there is no reasonable chance of it doing so. If it
  - **Fires** — Continue. If it has missfired repeatedly, a new mainspring should be put in.
  - **Missfires** — **WAIT 30 MINUTES FROM LAST TRIAL BEFORE OPENING BREECH! Examine firing-pin and mainspring. Commanding Officer at discretion may order breech opened after reasonable interval.**

Use of priming tools. In removing and inserting primers in turret guns, after a missfire, the tools issued for the purpose should be used. In case the missfire should develop into a hangfire, the recoil of the gun might seriously injure anyone attempting to prime without the use of the tool.

Calling missfire. Too much emphasis cannot be laid upon the necessity for the **pointer immediately calling " Missfire " as soon as he realizes that his gun has not fired after he has tried both electric circuits.**

PROCEDURE IN TIME OF WAR. Where the possible chances of serious danger due to missfires may be overbalanced by the more important considerations of battle, **the commanding officer may, at his discretion, decide what interval shall intervene between the occurrence of a missfire and the opening of the breech.**

SAFETY ORDERS GOVERNING USE OF BATTERY

(*Extract from Naval Instructions*)

Section 3. SAFETY ORDERS

2851. **Naked lights in magazines prohibited.** No naked light shall ever be taken into a magazine or other compartment containing explosives of any kind.

2852. **Live ammunition for drill prohibited.** Live ammunition will never be used for loading drill. The insertion of a live primer in a B. L. R. gun containing powder makes it live. Without the primer the charge is not live. Fixed ammunition and loaded and fused projectiles are live ammunition.

2853. **Plug face to be watched.** In every cartridge-case gun, except those of the sliding wedge or eccentric plug type, the breech-plug shall not be closed until the gun captain is assured that the front face of the plug is in normal condition (firing-pin housed, etc.).

2854. **Opening of breech during salvos.** Locking devices (salvo-latches) are being developed to prevent the breech of a loaded gun from being opened during salvo firing. Prior to the installation of these devices, whenever two or more guns are fired together, effective measures shall be taken to guard against opening the breech of a loaded gun. The salvo-latch shall be removed from or made temporarily inoperative on guns, the breech mechanisms of which are to be operated for purposes of drill, and such salvo-latches shall be replaced and made operative before firing is carried on with such guns.

2855. **Mushroom to be sponged.** The mushroom of every breech-loading gun shall be thoroughly sponged after each shot.

2856. **Posting of safety orders.** Copies of all safety orders and instructions pertaining to the armament of the ship shall be kept posted in convenient places easy of access to members of the crew, and all members of the crew concerned shall be **thoroughly instructed in them.**

2857. **Precaution against unlocked plug.** (1) It is possible to fire a screw breech-mechanism gun by percussion when the plug is swung home but not rotated and locked. Every possible precaution shall be taken to avoid accidents from this cause. If a gun be fitted for electric firing, with contacts so arranged that the plug must be fully rotated before the firing circuit is closed, it is not possible for an accident of this kind to happen.

(2) In a bag gun, where the lock is operated automatically, the automatic functioning of the lock should not be interfered with in any way. Should any of the parts operating the breech mechanism and the firing lock break, and the lock be then operated, the gun might be fired with the plug unlocked. Every possible precaution shall be taken to avoid accidents from these causes.

2858. **Close breech as soon as loaded.** (1) As soon as a gun is loaded, the breech shall be closed without delay.

(2) When a gun which has been fired is still warm when reloaded, and it later becomes necessary to remove the charge, the gun need not be fired but should be unloaded. When it is apparent that the service of the gun will not be resumed within a reasonable time, the powder involved will be dumped in distilled water, and kept in that condition until turned into a naval magazine at the first opportunity.

2859. **Tompions.** In preparing a battery for firing, the division officer shall assure himself that the tompion is removed from each gun and that each bore is clear.

2860. **Breech kept locked when primed.** (1) The breech of a gun shall never be unlocked or opened while there is a live primer in the lock.

(2) **Precaution with firing lanyard.** The firing lanyard shall never be hooked to the trigger of the lock until after the breech-plug has been closed and locked and the gun primed. The lanyard shall be hooked just before cocking the lock.

(3) **Breech kept locked while lock is cocked.** The breech of a gun shall never be unlocked or opened while the lock is cocked or while the lanyard is hooked to the trigger.

(4) **Cease firing.** When the order "Cease firing" is given, loaded guns must be put in such condition as to render accidental discharge improbable. This necessitates for —

B. L. R. guns	removal of primer
R. F. guns	removal of case

If a crew leave a gun at any time, the gun shall be left in the condition of cease firing.

2861. **Firing-pin housed.** (1) No cartridge-case gun shall be fired with a breech mechanism in which the firing-pin is not completely housed.

(2) **Condition of firing-pin.** As the firing-pin of every concentric-screw breech-mechanism is directly in rear of the primer when the plug is closed but not rotated, the utmost care shall be taken to insure that the firing-pin and all parts are in good condition, as the failure of a part of the mechanism might permit the firing of the gun before the plug is rotated.

(3) **Broken firing-pin.** The danger of a broken firing-pin point or of the fusing of metal on the face of the breech-plug, due to primer blowback, shall be constantly borne in mind and guarded against.

(4) In a cartridge-case breech mechanism having the firing-pin held in position by a cotter pin, similar to the five-inch Mark V mechanism, the cotter pin shall be in place at all times, in order to prevent the firing-pin from losing its housing. If the firing-pin be not housed, a premature explosion is apt to occur.

2862. **Priming.** The priming of a breech-loading gun while the breech is open is forbidden, and the breech shall be closed and locked before the primer is inserted in the

firing lock, except in a breech-loading gun in which the wedge block containing the firing-pin is arranged to operate automatically by the functioning of the breech mechanism, in such manner that the firing-pin cannot be brought opposite the primer until the breech is closed and locked.

2863. **Jammed cartridge-case.** No force greater than that which can be applied by the hand alone shall be used in loading a cartridge-case into a gun. Any cartridge-case that does not freely and fully enter the chamber of the gun under the influence of the force of the hand alone shall be carefully extracted and put aside. It shall be properly marked to indicate its condition, and shall be turned into store at the first convenient opportunity.

2864. The ramming of shells in turret guns by interposing sections of a powder-charge between the head of the rammer and the base of the shell is prohibited.

2866. **Care enjoined.** (1) The attention of all officers is invited to the necessity for the continuous exercise of the utmost care and prudence in handling of all kinds of ammunition.

(2) **Fire hose.** Whenever the guns of a vessel are being fired, the fire hose shall be led out as at fire quarters and the fire pumps shall be kept running.

(3) **Ammunition outside of magazines.** During firing no ammunition other than that immediately required shall be permitted to remain outside of the magazines.

(4) At target practice there may be assembled on deck no more than the necessary allowance of ammunition for the intermediate or secondary battery guns that are to fire on the next run; but no charge for a breech-loading gun shall be taken out of its tank, nor shall the top of the tank be removed until immediately before the charge is required for loading. For guns using fixed ammunition and for guns using separate powder charges put up in cartridge-cases the allowance required for the gun or guns that are to fire on the next run may be removed from the boxes.

(5) **Ammunition supply tests.** If an ammunition supply test is at any time required, the ammunition used therefor

will be target practice ammunition unless the order requiring the test authorizes the use of service ammunition.

2868. **Automatic shutters.** (1) In no case shall automatic shutters separating a turret from its handling room be secured in the open position during drills, exercises, or while the guns are firing.

(2) In developing the maximum speed of the cars the shutters shall be carefully watched and such adjustments made as may be found necessary. In case of damage to the shutters a report as to the extent and cause thereof shall be submitted without delay, which report shall state whether the trouble is due to faulty adjustment of the shutters or to excessive speed of the hoist.

(3) If the shutters be damaged during target practice so that they cannot fulfill their purpose, the guns of the turret concerned shall cease firing, and the firing from that turret shall not be resumed until the shutters of both guns are in working order, unless the hoist is of the trunked-in type, having automatic doors in the handling room which insure the separation of the turret chamber from the handling room, in which case the firing may continue so long as those automatic doors remain in efficient condition. In case the damage to the shutters cannot be repaired within a reasonable time, the crew of the turret shall fire the remainder of the allowance from another turret.

2869. **Sponging of guns.** (1) As there is an inflammable gas present in the chamber of a gun after firing, which under certain conditions may constitute a danger in igniting the exposed charge while the gun is being loaded for the next round, the chamber of every broadside breech-loading gun using charges that are unprotected by metal cases shall be sponged after each discharge before loading. In case of guns of this class, the combined sponge and rammer shall be used, with the bristle dampened with water. The sponge will be entered in the chamber immediately following the shell and shoved home as far as the shell, when seated, will permit, and then withdrawn. When the gun is sponged in this manner, it is not possible for inflammable gases or bits

of burning powder bags to remain in the powder chamber to endanger the ignition of the charge.

(2) **Gas-ejectors.** When adequate mechanical means have been fitted for the purpose of promptly clearing the chamber and bore of all gas, fragments of powder bags, etc., and when, after satisfactory trials, the same shall have been approved by the department, the foregoing precautions may be dispensed with; but in no case shall any of the precautions be omitted while using any extemporized blowing appliance, or when the approved appliance is not working at the standard pressure for which it was designed.

(3) **Loading turret guns.** In the case of turret guns, where sponging the chamber is impracticable, the danger from "flarebacks" or from the presence of inflammable gases or bits of burning material in the bore after firing, must be avoided by making sure that all parts of the bore are clear before the charge for the succeeding round is hoisted above the turret floor. In order to make sure that all danger of a premature ignition of a charge while being loaded has passed, a sufficient interval of time shall be allowed to elapse, after the breech-plug is opened, for the gas and smoke in the chamber and bore to dissipate; and the top of a loaded ammunition car shall not be brought above a horizontal plane 6 feet below the axis of the trunnions, nor shall powder-box doors be opened until the bore of the gun is clear.

(4) **Examination of bore.** When firing any powder-bag gun, whether fitted with gas-ejector or not, it shall be the duty of a member of the crew to look through the bore of the gun immediately after the opening of the breech and note when the bore is clear, announcing this condition by calling out, sharply and distinctly, "Bore clear!" In order to guard against the danger of flarebacks, the charge shall not be exposed at the breech of the gun until after the announcement "Bore clear." Exception is made of guns mounted on broadside mounts on weather deck, using powder-bags, not fitted with approved gas-expelling device; but in such the powder-charge shall not be exposed close to the breech of the gun until after the shell has been rammed home with

the standard combined bristle sponge and rammer wet with water and the mushroom has been wiped off with a wet sponge.

(5) **Cartridge-case guns.** The sponging of guns using fixed ammunition, where the charge is protected by a metal case, is not necessary, but before stowing the empty cartridge-cases below, steps shall be taken to free them from all inflammable gases. This can best be done by laying the cases on their sides and testing each one for the presence of gases by inserting a lighted taper in each case as far as the bottom, thus setting fire to any inflammable gases, or by washing the cases out with soap and water.

(6) **Strengthening cartridge bags.** Under no circumstances shall the material of the cartridge bags or strengthening tapes be added to without authority. Should it be necessary to stiffen the charges, additional cloth or tape shall not be used, but, if necessary, the old cloth or tapes shall be retied or replaced by new material similar to the old.

(7) **Magazine flap-doors.** The magazine flap-doors of only such magazines as are being used to supply charges shall be open, the flaps, in all cases, being down except during the time of actual passage of the sections of the charge through the door.

(8) **Unnecessary exposure of charges prohibited.** There shall not be exposed (removed from the tanks) at one time, in all the magazines in use, more than one charge for each gun, and then only as necessary to supply the demand in the handling room; nor shall there be permitted at any time an accumulation of exposed sections for more than one charge for each ammunition hoist outside the magazines in the handling room.

(9) **Safety order to be posted.** A copy of this article shall be posted in every turret and in every handling room, together with the other safety orders pertaining to the turret and the handling room.

2870. **Inspection of recoil-cylinders.** Before the firing of any gun, other than for saluting, the commanding officer shall require a report that the recoil-cylinders have been

inspected and filled in the presence of the gunnery and division officers.

2871. **Blind shell for sub-caliber.** Only blind shell shall be used for sub-caliber or ex-caliber practice.

2872. **Care in loading.** Especial care shall be exercised to see that all sections of powder-charges are entered in the chamber with the ignition ends toward the breech.

2873. **Removal of fuses.** (1) Fuses shall not be removed from loaded shell except under explicit instructions from the Bureau of Ordnance.

(2) Any loaded and fused projectile which may be accidentally dropped in service from a height exceeding 10 feet should be set aside and turned in to a naval ammunition depot at first opportunity. Such a projectile should be clearly marked to indicate its condition and should be handled with the greatest care. On receipt at the magazine it shall be unfused and the fuse scrapped.

2876. **Various other conditions.** Conditions not covered by these safety instructions may arise which, in the opinion of the commanding officer, may render firing unsafe. Nothing in these safety instructions shall be construed as authorizing firing under such conditions, or as preventing the commanding officer from issuing such additional safety orders as he may deem necessary.

Chapter XXII

CARE AND PRESERVATION OF BROADSIDE AND TURRET GUNS AND ACCESSORIES

CARE AND FILLING OF RECOIL CYLINDERS — CARE OF SIGHT MECHANISM AND TELESCOPES — RENEWAL OF GAS CHECK PADS

GUNS AND GUN MOUNTS — ROUTINE FOR CARE AND CLEANING —

Every gun shall be trained and elevated to its full extent once each day, except on Sundays, holidays, on days when coaling ship, and at sea when heavy weather interferes. This serves to keep the mechanism in proper working order, preventing the operating gear from sticking or "freezing", as it is termed. Every other working part of the battery must be operated each day for the same reason.

All guns, if not fired, shall be run in once each year. When a gun is fired, it recoils back through its slide. If a gun has not been fired for a year, it is likely that it may be stuck or frozen in its slide. To "run the gun in" is to cause it to come back through its slide, so that the working surfaces may be cleaned and the recoil mechanism overhauled. It is effected by releasing the counter-recoil spring and emptying the recoil cylinders.

The **bores of guns** shall be kept thoroughly clean and **lightly coated with oil.** They shall be examined frequently (every two or three days) and the coating renewed when necessary. **Particular attention must be given to the slope and origin of rifling** to keep them well oiled and free from rust.

Every fair day the tompion, or round wooden block set into the gun muzzle to protect it from weather and sea conditions, **is removed** and the compression slope in the gun cleaned and re-oiled.

All bare metal or bright steel parts of gun and mount must be kept lightly oiled or vaselined as a precaution against rust. This must be gone over daily and the oil coating must never be permitted to get gummy or sticky, with dust and small particles adhering to it. **All bright work (brass) such as sight gear,** etc., is polished or shined each day by the members of the gun crew.

The roller bearings and path between the stand and carriage must be well oiled once each week.

The gun carriage must be raised or lifted from the stand once every three months, the roller or ball-bearings removed and rollers and path cleaned.

Training and elevating gear must be removed from the gun once each month and thoroughly cleaned. At all times this gear must be kept clean, and all steel parts well oiled, excepting, of course, friction training gear, when this is used.

Oil and grease cups must be kept filled to insure proper lubrication of the parts. They must be inspected before the gun is operated or tested in order that the bearings will have sufficient lubrication.

All axles, such as those of trucks, elevating and training gear and bolts serving as axles, such as yoke and pivot bolts, elevating-arc bolts, etc., **are to be removed, cleaned, and re-oiled once every two months,** or oftener, if circumstances render it necessary.

The **ball-bearings and rollers** of **broadside mounts must be kept clean and well oiled** to prevent sticking or rusting. The **oil channels in the slide of a mount** of this type must be kept clear of dirt and should be filled with oil before the gun is fired.

Machine Guns and Automatic Guns should be kept covered with the canvas covers provided when there is any likelihood of their being affected by coal dust, grit, etc., or

by salt water during heavy weather. **These guns must be completely dismounted and thoroughly cleaned and re-oiled once each week.** In re-oiling, first wipe off all the old oil which may be clogged with dust and grit. **The rule for keeping these small guns covered with canvas covers when coaling ships, etc., applies also to other minor-caliber guns.**

In cleaning the gun, brick dust, emery paper, or other gritty substances must never be used on any part of it.

No part of the mechanism must ever be scraped with knives or metal scrapers, or be defaced or roughened in any manner.

The gun should be kept closed at all times, the breech plug covering the breech end; and a tompion, the muzzle end. This protects the bore and interior of the gun from dust, grit, weather and sea conditions, etc.

Lubrication of a gun and its mount and accessories is the secret of proper maintenance. Various grades of oil are used. **A heavy oil is usually considered preferable for heavy bearings of comparatively slow-moving parts such as the trunnions, etc.** This heavy oil has the disadvantage of often clogging the bearings, and they should be frequently washed out with kerosene, which prevents the oil or grease from hardening. **A light oil should be used on exterior bare metal parts of the gun and a light grade of pure mineral oil is used on the variable speed gears and on other intricate mechanical parts, such as sight gears. All roller and ball-bearings should be well packed always in clean vaseline. All gears require a fairly heavy grease**; vaseline is probably best for this purpose. The operation and heating up of the gears often causes the lubricant to ooze out of the gear box. The remedy is to use on them a little heavy grease, mixed with powdered graphite.

In general, be sure that you use the best available lubricant for each particular purpose and use plenty of it.

Keep all trace of oil and grease away from the contacts of your electrical firing mechanism and away from the primer seat.

Keep all oil holes plugged with leather. This keeps dust and dirt from them. Also, in heavy weather, it keeps sea water from filling oil holes.

FRICTION DISKS OF TRAINING GEAR — CARE

The majority of broadside or intermediate battery guns are trained by friction training gear. The friction disk mounted on the stand of the gun mount must have a rough, abrasive surface to facilitate training of the gun. **These disks should be kept clean, however, and perfectly free from oil or other lubricant. Washing in lye water and then thoroughly rinsing in fresh water will remove all trace of oil or grease.** In disks of the multiple type it has been found that one man, using a 24-inch wrench, can set them up sufficiently hard.

BREECH MECHANISMS — CARE AND CLEANING

All breech mechanisms must be cleaned daily, avoiding the use of any gritty substance. On those breech mechanisms where the plug is carried on a plug-tray, the plug should be frequently (every three or four days) removed from the tray so that the threads at the bottom of the plug may be reached for cleaning.

The parts of breech mechanisms should be kept lightly vaselined. This is wiped or cleaned off each morning and the mechanism given a new coat.

The **breech operating gears and the plug and screw-box threads** should be carefully watched and frequently tested to see that they operate smoothly and without lost motion. Lost motion can be remedied by tightening up the particular parts concerned. If they are old and worn out, the parts should be replaced as soon as possible. Probably there are spare parts in the Ship's Ordnance Storeroom.

Difficulty in opening or closing the breech, or a hard-working breech, is often caused by burrs on the threads of plug or screw-box, caused by a knock. Such burrs can

be removed with a small half-round file, but it must be done very carefully in order to prevent damage to the breech mechanism.

FIRING MECHANISM — CARE

The firing mechanism for both rapid-fire and separate ammunition guns is probably the most intricate mechanism on such guns. Naval Instructions state particularly that every effort shall be made to keep the firing mechanism of every gun in a thoroughly efficient condition, inasmuch as a defect in this mechanism may cause the gun to be fired prematurely.

The **seat of the primer** in the case of separate ammunition guns can be considered in connection with firing mechanisms. Care must be exercised to keep the primer seat, which is in the after end of the mushroom stem, thoroughly clean and smooth, and free from oil so that electrical firing will not be interfered with. **The primer itself must fit closely in the primer seat.** Otherwise the primer may be blown back, possibly disabling the firing mechanism. This is called a "primer blowback." The "taper reamer" or tool provided for clearing out the primer seat should be used very seldom. Frequent use is inclined to wear and enlarge the primer seat.

PAINTING OF GUNS

The chase of guns, extending from the muzzle back to the slide cylinder of the gun barrel, is usually given a coat of red lead over the base steel to protect it and then painted war color. **It is important that no part of the gun barrel that comes back into the slide of the mount during recoil of the gun shall be painted.**

The various parts of the gun mount, **except bearings and working surfaces**, are usually painted war color for protection and maintenance.

RECOIL CYLINDERS — CARE, MAINTENANCE, AND METHOD OF FILLING

It is required by Naval Instructions that all recoil cylinders on a ship be inspected, cleaned, and refilled directly after a vessel is commissioned or placed in active service and at the end of each year thereafter.

The liquid used to fill the cylinders is a mixture by measure of twenty parts of water and eighty parts of glycerine. The water used must be clear of alkalies and mineral salts; otherwise the insides of the cylinders will be corroded. The glycerine must be free from fatty acids. Certain chemical tests are prescribed for testing the liquid. These tests you will find described in detail in "**SHIP AND GUN DRILLS — U. S. NAVY.**"

The liquid in the cylinders usually becomes muddy when it has been standing for a considerable time, and when this occurs, a thick, pasty sediment may be formed in the grooves in the walls of the cylinders, clogging them, and thus interfering with the proper recoil of the gun. It is mainly for this reason that the cylinders are required to be emptied and cleaned once each year.

When exposed to heat, glycerine expands, and, if so exposed for a considerable length of time, gums, thus clogging the grooves, etc., and causing the gun to function improperly. This expansion of the glycerine in hot weather often produces an internal pressure in the cylinders, and the liquid escapes or leaks around the bonnets, stuffing-boxes, etc. This is remedied by removing the filling plug and permitting the surplus liquid to escape, relieving the pressure.

In cleaning cylinders in which the liquid has gummed, this gummy substance can most easily be removed with a strong lye or soda solution, but the cylinder must be well cleaned out afterward with fresh, clean water.

An equalizing pipe or a circulating pipe always connects the recoil cylinders when more than one such cylinder is fitted to the gun. The liquid circulates through this pipe from one cylinder to the other, and its purpose is to equalize

the pressure in the cylinders on the recoil and counter-recoil of the gun. **Special care should be taken to see that this circulating pipe does not become clogged, and it must be thoroughly cleaned whenever the cylinders are emptied.** A good test to see if the circulating pipe is clear is to blow through the filling holes of cylinders before refilling them.

During the daily inspection of the gun, particular attention should be given to the recoil cylinders, in order to ascertain if there is any perceptible leak. Any leak will be corrected at once and the cylinder immediately refilled to capacity. Before every firing, unless an emergency makes this impracticable, the recoil cylinders shall invariably be examined and filled, if necessary.

FILLING RECOIL CYLINDERS. Broadside Guns, with two recoil cylinders — 4: 5: 6: 7-inch Calibers. — If the filling plug is in the rear of the cylinder, as is usually the case, depress the gun muzzle slightly. Remove the filling plugs of each cylinder, or if an air hole is provided, remove the plug from the air hole of the cylinder opposite to the one in which the liquid is to be poured. Pour the liquid in the filling hole of one cylinder until it runs out of the opposite cylinder; then replace plugs.

If the filling holes are in the forward end of the cylinders, elevate the gun muzzle slightly; if in neither end, but somewhere in the body of the cylinder, keep gun level.

If no air hole is provided for the escape of air as the liquid is poured in, care must be taken to pour the liquid slowly and in small quantities. **Care must also be taken to measure accurately the quantity of liquid poured into the cylinder and to strain it through a piece of bunting or cheesecloth to prevent the entrance of dirt.**

Minor-caliber Guns with one recoil cylinder — 6, 3, and 1-Pounders. — On the majority of these small guns, only one filling-hole is provided in the after end of the cylinder. To refill depress the gun muzzle slightly and proceed as outlined for broadside guns.

SIGHT MECHANISMS AND TELESCOPES — CARE AND ADJUSTMENT

The construction and operation of sights, telescopes, and sight mechanisms has already been covered in considerable detail. Here it is the aim to lay down a few rules for the care and the maintenance of this equipment in good condition.

Open or peep sights are fitted to most broadside guns in addition to the regular telescope sights. These are for auxiliary use, but often in bad weather and for comparatively short ranges they will be found more practicable than the telescopes.

CARE. — **All working parts of the sight mechanism must be kept free from grit and dust and be kept covered with a coating of good mineral lubricating oil.** Oil holes are provided to all bearings and gears of sight-operating mechanism.

Sights that are exposed to salt spray should be disassembled, cleaned in alcohol, covered with a fresh coating of oil, and reassembled. This should be done as frequently as is necessary, it being left to the discretion of the gunnery officer of the ship to take such action whenever conditions warrant.

Emery paper or any other gritty substance must never be used on any part of the sight mechanism. The adjustments are so fine, that any use of these substances would cause lost motion or looseness in the gears and so ruin the accuracy of the sights.

Lost motion in the sight-operating gear must be constantly watched for by the gun division officer, and frequent tests should be made, where the sighting gear is used to any extent, as for drill purposes, to see if any lost motion has developed.

To test a sight for lost motion proceed as in bore-sighting. After bore-sighting, move sights back and forth, returning each time to zero setting. If all telescopes intersect at the target each time your sights are at zero, you have no lost

motion. If they diverge differently each time at zero, lost motion exists. If lost motion has developed, the refitting of the sight should be done only by a skilled mechanic.

In guns where multiplying range and deflection scales are used, that is, range dials and azimuth-drums instead of the simple, direct-reading scales, lost motion frequently develops in the multiplying gears. They should be frequently tested for this. The existence of the lost motion can be easily detected and easily adjusted by taking up slightly on the gearing.

TELESCOPES — CARE AND MAINTENANCE

Telescopes are particularly delicate and fragile and require the best of care and attention. The lenses especially must be carefully looked after.

No other than the specially provided material will be used for wiping lenses; and lenses will be wiped, even with this material, only when absolutely necessary. The use of a handkerchief or neckerchief must be avoided.

All telescopes should be provided with canvas covers, as nearly as possible moisture and dust proof, and which can be readily removed. When telescopes are not actually being used, this cover should be on; also the objective lens dust cap should be in place.

The outside of telescopes should be cleaned or dried, when necessary, with a dry, soft cloth only. This cloth should never be used on the lenses.

Telescopes should be protected from moisture, and the lenses should be protected as far as possible from direct sunlight, as it crystallizes the balsam in cemented lenses.

No gritty substance should be used on any parts of telescopes.

The illuminator caps should be kept clamped in place at all times, except when cross-wire illumination is being used. **Great care must be exercised to prevent water or dampness getting inside the telescope.**

Lenses should not be touched with the fingers and should

be wiped off only when necessary. Ordinarily only the objective and rear eye lenses require cleaning.

The proper way to clean a lens is to blow hard on it to remove all the dust, dirt, and grit possible; then brush off the remaining particles with a clean, dry, soft camel's-hair brush, and then polish gently with selvyt, chamois, or the special lens paper supplied.

Any moisture or sweat on objective or rear eye lens should be removed with the special lens paper as soon as practicable.

When telescopes are not being used, a plug of loosely folded lens paper in the rubber eye guard is very convenient for keeping dust and dirt off the rear eyepiece lens. A "pillow" of chamois skin is also recommended.

The telescopes should not be disassembled on board ship except in emergency. Navy yards should clean and overhaul them.

Never use waste on telescope lenses. Never use oil on telescopes or lenses.

GAS-CHECK PADS — CARE, ADJUSTMENT, AND RENEWAL

One of the greatest advantages of the De Bange gas-check system, in addition to the effectual check it provides, is the ease and rapidity with which a defective pad can be replaced in an emergency; also the pads are easy to maintain and the life of a pad is comparatively long.

Spare gas-check pads and spare gas-check rings are issued with each separate ammunition gun. These spares are kept in the ship's ordnance storeroom. Before being issued these spares are carefully fitted to the guns and are not likely to give any serious trouble in being attached and adjusted.

The adjustment of a new set of gas-check rings or of a new gas-check pad to a breech plug must be very carefully done in order that the operation under firing conditions shall be proper and the gases from the explosion of the powder be effectually checked. The bearing of the rings and pad in the gas-check seat of the gun should be verified

by making chalk marks, parallel to the axis of bore, at several points around the circumference of the gas-check seat. Close the breech and open it again. If all chalk marks appear transferred to the gas-check pad and rings, they are properly adjusted centrally. The longitudinal adjustment or the tension on the pad and rings is effected by tightening the nut on the end of the mushroom shank, located in a recess in rear of the plug. If this last adjustment is correct, the mushroom head can just be turned by a man using both hands. Pad must be smooth and intact all around, the rings being flush with it.

The life of a gas-check pad, while extending usually over a large number of rounds of firing, is variable, and depends to a large extent on the care it receives.

CARE. — The pad and rings should be protected from the weather and everything that might indent or bruise them.

Both rings and pad should be kept scrupulously clean and well-oiled, using soft rags or pieces of waste.

Neither rings nor pad should ever be cleaned with any gritty substance.

The pad must be habitually coated with tallow.

Hardening of the pad is remedied by soaking it in a hot mixture of oil and tallow.

If the canvas cover over the pad becomes slack or loose at any time, renew the pad.

RENEWAL OF A GAS-CHECK PAD is, under ordinary circumstances, a simple procedure. All that is necessary to do is to come up on the nut on the rear end of the mushroom shank, remove mushroom and shank from the plug, replace the gas-check pad or rings with new, and reassemble on the plug, being careful to see that adjustments are proper.

To shift or renew the pad while firing the gun is somewhat more difficult. If, during firing, the pad disintegrates to a point where renewal is necessary to a continuation of the fire, it will be very hot and mushy. Also the mushroom head will be too hot to handle. A small net is provided which fits snugly over the mushroom head, holding it while

the pad is being shifted. A small tackle is also provided to take the weight of the mushroom in the net. Therefore the pads can be shifted in the same manner as described above and without the necessity of touching the hot metal parts with the hands.

ELEVATING AND TRAINING GEAR — LOST MOTION

Elevating and training mechanisms of both the geared and friction types have been fully discussed in connection with gun mounts.

Where gears are utilized there is always a possibility that lost motion will occur. This is undesirable, as in the excitement of firing during an engagement or even practice, if a pointer or trainer moves his operating wheel a certain amount, he expects a corresponding motion of the gun. Not getting this motion of the gun, due to lost motion in the operating gears, is bound to result in poor shooting.

There are various ways of adjusting the gears to eliminate this lost motion. The methods vary with different caliber guns and different "marks" and "modifications," but usually some part is made adjustable for the very purpose of taking up this lost motion. Lost motion of this nature is easily detected, merely from the manner of operation of the gun in train and elevation.

TURRETS — GENERAL CARE AND MAINTENANCE

All of the rules that have been laid down in the foregoing have applied equally well to the turret as to the broadside guns.

There are, however, several points with regard to the care and maintenance of turret guns that are especially applicable to these guns, and it will be endeavored to cover these points briefly.

CARE. — All parts of the turret, turret machinery, and gun fittings must be kept clean and free from rust. All working parts must be kept well lubricated. No fresh

lubricant should be applied to any part without first removing the old coating and thoroughly cleaning the part.

Operating levers, valves, rollers, roller-paths, ammunition hoists and cars, handling-room gear, etc., should be free and clean from paint, and should be occasionally wiped with an oily rag to prevent rusting. These parts should not, however, be considered as bright work.

Roller paths and rollers should receive particular attention. They should be examined once each week by the turret officer, who should assure himself of their cleanliness and freedom from rust.

Before a turret is trained, the roller-path should be carefully inspected to see that it is free from obstructions; also it should be well-oiled and all holding-down clips should be secure. Roller-paths are often neglected because they are difficult of access and the lubricant in them often becomes heavy with dust and dirt. Light oil is more efficient than heavy grease. Keep the paths lightly oiled, but do not permit them to become dry. **Caution all men not to leave tools, cleaning rags, or other implements on the roller-path.**

Also, before training, ease up on the holding-down springs of the water-shed, or raise the water-shed, if practicable; see everything clear outside of the turret and in the path of the guns and see everything clear in the handling-room.

Ammunition hoists must be given particular attention in order that they operate properly at all times. **The cables particularly must be kept well lubricated. Graphite is best for this purpose.** Slack cables must be immediately shortened. A cable rusted or with a strand parted must be immediately replaced.

PAINTING. — The inside of the turret, including the sides, the top, and those platforms not ordinarily trod upon by the crew, should be painted white — preferably with white gloss paint to give as much light as possible. No colored paint should be allowed except that the slits in the sighting hoods should be painted a medium shade of green, as should also a section of the turret roof in front of each

telescope. This is easy on the eyes of the operators and there is no glare from it.

Gun muzzles outside the turret are, of course, war color on red lead, as with broadside guns. Painted parts of the mount inside the turret should be white — otherwise kept bright. Tools, racks, rails, etc., should be kept bright — never painted.

Turret captains are permitted to live and sleep in their own turrets. They should never, however, be permitted to have their gear, hammock, ditty box, etc., lying about in the turret. Inside the turret everything should always be clean and ship-shape.

Smoking should never be permitted inside a turret.

MISCELLANEOUS ORDNANCE EQUIPMENT AND INSTRUCTIONS AS TO CARE

Torpedo tubes, air compressors, and gas ejectors shall be manipulated once each week.

All ammunition hoists shall be tested weekly, without load, five minutes hoist and five minutes lower.

Erosion of the gun bore occurs after a certain number of rounds have been fired from the gun. The shell will be seated farther and farther into the bore as erosion progresses. **Frequently measure the distance from muzzle to base of seated projectile.** This distance should be the same in all guns of the same caliber in a battery. If, on account of erosion, the shell seats at different distances in various guns of the same caliber, this fact must be reported to the gunnery officer of the ship and he will make allowance for it to eliminate dispersion of fire.

In loading a gun, special care must be taken not to injure the gas-check slope. If the slope is injured, the escape of gas to the rear cannot be prevented and serious damage may result.

Particular care must be taken in the use of the battery to see that the choke of the gun is not so great as to overcome the clearance between the bore and the bourrelet

diameter of the shell. This clearance should never be less than the one-hundredth part of an inch.

In assembling any part of ordnance gear or mechanisms, avoid the use of force. All parts are made and matched to fit together easily and if they do not they have not been properly assembled.

When first assigned to any turret or broadside gun division, carefully inspect all parts of guns and gear. Have all parts cleaned and overhauled. If unfamiliar with any particular part, make a study of it. Never attempt to dismount or disassemble a part of any mechanism until you are thoroughly familiar with its details. Check up the allowance of space parts and tools for your battery and their stowage.

ORDNANCE EQUIPMENT DRAWINGS AND PAMPHLETS—SPARE PARTS

Every ship has on board in the custody of the Ordnance officer complete drawings and plans covering every detail of guns and ordnance equipment on that ship.

Ordnance pamphlets are furnished in addition to the blueprints. These describe in detail certain mechanisms and their manner of operation; also the particular care to be taken in their maintenance. Ordnance pamphlets can be secured covering gun mounts, breech mechanisms, firing mechanisms, and in fact, almost any detail of the ordnance equipment.

Frequent reference should be made to drawings and pamphlets by a battery officer until he is sure that he is thoroughly familiar with every part of his battery and its operation.

An Ordnance storeroom is provided on every ship. A gunner's mate, first class, is usually in charge, as storekeeper. All spare parts such as are furnished with each gun, and all ordnance gear not in use, is kept in this storeroom. It is issued out only on receipt.

Spare parts are supplied to ships not only for minor

parts of the breech mechanism, sights, etc., but for nearly every principal part of the gun mount. When a ship is cleared for action, these spare parts should be placed in a previously designated position, convenient to the battery, so that a defective part can be quickly replaced. **Guns of the same caliber and type (Mark and Modification), mounted in the same broadside of a ship, are so constructed that any part or parts are interchangeable.**

BATTERY LOG. — Every officer in charge of a broadside battery or of a turret should keep a log — in the latter case a "**turret log.**" This log or notebook should be kept "to date." It should show what repairs were made each day; what gear overhauled; the general work done and the condition of the battery or turret. It should also contain a record of target practice and the names of men under instruction as pointers, trainers, gunner's mates, etc. In fact, it should contain all information of interest or value.

On some ships, gunnery officers require smooth logs to be submitted weekly.

GUNNER'S MATES are assigned to particular guns and they are responsible for the care and general maintenance of their gun or guns, as has been outlined. On a broadside battery one gunner's mate usually looks after from four to six guns. He has assistants who are assigned as "strikers." These are seamen selected for their aptitude for this class of work.

A **turret captain** is in charge of a turret and is assisted by "strikers" or "gunner's mates."

These petty officers are usually reliable and are specially trained in their work. **A divisional officer should not, however, leave the battery entirely to his petty officer, but should himself make a thorough daily inspection.**

Gunner's mates cannot serve as members of gun crews. They are a part of what is known as the "gunner's gang" and are needed to make emergency repairs during a battle. They are held in reserve for this purpose.

The members of gun crews are responsible for cleaning the brass or bright work on their own guns each day before morning inspection or quarters.

Gun pointers and trainers are responsible for training and elevating, through their full arcs each day, the particular gun at which they are stationed.

Turret trainers are responsible for training their turret through its full arc each day, and the individual turret gun-pointers the elevation of the guns.

Men regularly stationed at ammunition hoists are responsible for their weekly testing.

All other tests called for are made by the gunner's mates and turret captains. These men should superintend all tests on their own guns, no matter by whom they are made.

PRECAUTIONS BEFORE FIRING

Carefully clear all oil out of powder chamber and from the mushroom head.

See that recoil cylinders are filled properly.

If there is time, dismount and examine breech mechanism carefully. Examine the gas-check pad for cracks, smear well with tallow, and set up hand taut. Have a can of tallow at hand during firing. See that split rings are turned so that splits are at opposite ends of diameter. See that primer vent is clear in wedge of firing lock. See that firing-pin is straight, unbroken, and clear of seat in wedge.

Test firing connections — fire a test primer.

CARE AFTER FIRING

After firing, that is, when you are through firing for the day or for a considerable length of time, wash the gun out with a hose and a bristle-bore sponge. The gun muzzle is depressed, and the hose nozzle is placed in at the breech end of the gun. **After the bore and chamber have been thoroughly washed with fresh water, dry them carefully with a sheepskin sponge. Then pass a sheepskin sponge well-coated with oil through the bore several times.** This oils the bore; also oil the chamber.

In the absence of sheepskin sponges, wrap a piece of old

blanket around the sponge cylinder. First dry the bore with it — then oil another piece of blanket and oil the bore by passing it back and forth through the bore several times wrapped around sponge.

After firing a gun of six-inch caliber or smaller, completely dismount the breech mechanism; wash every part in warm fresh water and soap, dry and rub with a well-oiled rag. Reassemble the mechanism.

Turret gun mechanisms are too heavy to dismount completely, but they are thoroughly cleaned and re-oiled after firing.

After firing, remove mushroom and gas-check pad as soon as practicable and clean and oil them.

CHAPTER XXIII

TORPEDOES

GENERAL FEATURES — WHITEHEAD AND BLISS-LEAVITT TYPES — METHOD OF FIRING

All our torpedoes are called " automobile torpedoes " for the reason that they provide within themselves their own motive power. The mechanism is complete in itself, both fuel and engines being a part of it, and these operate to propel the torpedo through the water after it is fired from a ship.

Until recently there have been in use in the Service two principal types of torpedoes: the Whitehead and the Bliss-Leavitt.

THE WHITEHEAD TORPEDO is fitted with 3- or 4-cylinder reciprocating engines; this is its distinctive feature. In all other respects it is identical with the Bliss-Leavitt, the essential features of which will be briefly described. It is understood that Whitehead torpedoes are no longer issued to the Service.

THE BLISS-LEAVITT TORPEDO is fitted with turbine engines of Curtis design, this being its distinctive feature.

The following are the essential features of any torpedo, including the Bliss-Leavitt.

AIR-FLASK: The air-flask or chamber is located in the torpedo directly in the rear of the " head ", which we will take up later. **Compressed air is the " fuel " that operates the torpedo engines.** The air-flask is kept charged with air, compressed at pressures up to 2250 pounds per square inch. In time of war or at any time when contemplating firing, the air-flask must be kept charged at maximum pressure.

HOT– AND COLD–AIR TORPEDOES: In what we call a **hot-air torpedo,** the compressed air passes from the air-flask into a **combustion chamber,** before being utilized to operate the torpedo engine. **In this combustion chamber or flask, the cold compressed air is heated by the burning of alcohol in contact with it.** Heating the compressed air causes it to expand, and so increases the pressure that the quantity of air carried will last a considerably longer time than otherwise; the pressure being the predominating factor in the operation of the torpedo engine. **It is conservatively estimated that the range of a hot-air torpedo is about double the range of one of the cold-air type.**

TORPEDO WAR AND EXERCISE HEADS

The head of a torpedo is detachable, so that a head of either the war or exercise type may be fitted, depending on the purpose at the time.

The head is somewhat hemispherical and is located at the very forward end or point of the torpedo.

WAR HEAD: This head is used in action. It is filled with some very high explosive. **Until recently wet gun cotton was solely used for this purpose, a weight of 140 pounds of it representing a normal charge,** although charges up to 300 pounds were in use in particular types of torpedoes.

On impact with a solid body, during its run, the charge of wet gun cotton in the war head of the torpedo is exploded, fragmenting the head of the torpedo and any object in contact with it or near it at the time.

The war head is fitted with a war-nose, which is somewhat in the nature of a plunger in the very nose or point of the war head. On impact of the torpedo, this war-nose drives against a fulminate of mercury percussion cap, which explodes in contact with a dry gun cotton primer. The dry gun cotton primer, in turn, explodes the wet gun cotton charge and the torpedo.

EXERCISE HEAD: For drill purposes an exercise head is fitted in place of the war head. **This head is the same shape**

and weight as the war head, but contains no explosives; the head is filled with water to bring it up to standard weight.

HYDROSTATIC GEAR: This mechanism causes the torpedo to travel at a continuous "set" depth below the surface of the water. Briefly, it is effected by the different pressure of the water, at varying depths, operating against a piston or spring, which is connected up with a horizontal rudder in the tail of the torpedo. **Before the torpedo is fired, it is "set" to travel level at a certain depth; in this setting a certain tension is set up in the spring. At the desired depth, the tension on the spring and the pressure of the water against it will compensate each other and the rudder will be parallel.** If the torpedo should go deeper than the "set" depth, the pressure of water overcomes the tension in the spring and tilts the rudder upward slightly, bringing the torpedo back to its normal level; and vice versa, if the torpedo goes higher than the "set" depth, the tension in the spring overcomes the water pressure and tilts the rudder downward. In this manner the torpedo soon adjusts itself and travels level with the surface at a uniform depth. **The hydrostatic gear is located in an immersion chamber.**

PROPELLERS: Two propelling wheels are fitted to a torpedo, being located in the tail of it. **These propellers revolve in reverse directions; one right and the other left.** In this manner the steering of the torpedo in a straight line is simplified.

OPERATION OF THE ENGINES: The engine compartment is located in about the center of the body of the torpedo. The engines are connected by suitable valves and piping to the compressed-air supply in the air-flask. **By the operation of suitable valves during the firing of the torpedo, its engines do not operate, until the throttle-valve is opened by the torpedo taking the water, as it does, in a long, flat dive.** This prevents injury to the torpedo by its propellers "racing" before it strikes the water.

The **TAIL** of the torpedo is very finely adjusted. It carries vertical and horizontal rudders and the propelling wheels.

GYROSCOPE — STEERING GEAR: The gyroscope is a mechanism designed primarily to keep a torpedo true on its course. It is connected up with the vertical rudder in the tail of the torpedo and operates it. The gyroscope itself is nothing more than a constantly spinning wheel with its axis in the fore-and-aft line of the torpedo. The principle of the gyro is that spinning constantly in a certain plane at high velocity it has a great tendency to continue spinning in that same plane and will resist any effort to turn it into another plane.

Therefore, the gyro, mounted and spinning in the torpedo, has a tendency to continue spinning in the same plane. If, now, the torpedo should verge to right or left of the course, the gyroscope will resist this change, and its resistance will be brought to bear on the vertical rudder so that the torpedo will maintain its original direction.

If it should be desired to fire the torpedo so that it will take up and maintain a certain course after firing, which will be practically independent of the course of the firing ship, set this course on the gyro, which will start spinning in the plane of the course desired. **When the torpedo takes the water, the gyro will operate the vertical rudder, causing the torpedo to follow the course set.**

Certain mechanism is also provided, so that the gyro will not take control of the steering of the torpedo until it has traveled a certain distance from the firing ship. At the end of this distance, the gyro takes control and turns the torpedo to the course at which the gyro has previously been set and in the plane in which the gyro is spinning. **This ability to change the course of a torpedo after firing is a valuable feature.**

SIZE, SPEED, RANGE, ETC.

The average practical range of the modern torpedo is from 3000 to 4000 yards, although there are a number of torpedoes in use and still being issued that have a range of 10,000 yards.

With the increased accuracy of control of torpedoes that

has been developed recently, these long-range torpedoes are coming into practical use.

The present average speed of torpedoes is approximately 30 knots per hour, although for different types this speed averages between 30 and 40 knots per hour.

In size, a good representative type of modern torpedo is 45 centimeters (17.7 inches) in diameter and 5 meters (16 feet 4 inches) in length. Other torpedoes of various sizes are in use up to 21 inches in diameter and 21 feet in length.

METHOD OF FIRING TORPEDOES

LAUNCHING TUBES: These are the tubes from which the torpedoes are fired. On battleships or any ship of a larger type, torpedo tubes, if carried, are under water, and the torpedo, when fired, passes through sluice gates in the ship's side. On a destroyer or torpedo boat, tubes are carried on the top deck.

After all settings and adjustments have been made, the torpedo is loaded into the tube and the tube doors closed. **A small charge of powder, called an impulse charge, is inserted in a receptacle, and the firing mechanism is cocked. The torpedo is now ready to fire.** The pointer quickly aims the tube, and when his cross-wires are "on", fires. The impulse charge explodes and the torpedo is forced out through the tube, taking the water, as explained before, in a long, flat dive, which causes the torpedo engines to operate. This description of firing refers, of course, to an open tube mounted on the deck of a destroyer. In the case of submerged tubes, the method is similar, except that the tubes cannot be aimed; the firing ship must instead change her course as necessary. Torpedoes are fired from submerged tubes by means of compressed air.

Chapter XXIV

AUTOMATIC MACHINE RIFLES

COLT; BENET-MERCIE; AND LEWIS TYPES; — DETAILS OF MECHANISM AND PRINCIPLE OF OPERATION — CARE IN FIRING AND IN MAINTENANCE

THERE are two principal types of automatic machine guns or rifles in general use at the present time. The first of these is the **Colt Automatic Gun, Mark I, Mod. I**; the second is the **Automatic Machine Rifle, Mark II.** (*Benet-Mercie*)

All automatic rifles are essentially small arms, using .30 caliber small-arm ammunition. They differ from small-arm rifles in that they are considerably heavier, and their mechanism is more intricate, containing **an automatic feature which will cause the rifle to fire automatically and continuously as long as pressure is maintained on the trigger and ammunition is properly supplied.**

Automatic rifles find their principal use in connection with landing-parties on shore, as they are light and easily handled. For shore purposes, these rifles are mounted on two-wheeled field carriages of light construction.

They are also used extensively lately as a battery on small patrol boats, being mounted on tripod stands, usually forward and aft on deck. Battleships are fitted with sockets on the quarterdeck to receive tripods of rifle stands. On the quarterdeck of a large vessel, these rifles would be used to repel boarding parties in small boats.

COLT AUTOMATIC GUN, MARK I, MOD. I

MECHANISM AND PRINCIPLE OF ACTION: The rifle consists of a detachable barrel with a breech casing,

in which the mechanism for charging and firing the gun and for ejecting the empty cartridge case is contained.

The cartridges are automatically fed to the gun by means of canvas web belts, operating from left to right. The belt is contained in a box, which is attached to the breech casing of the gun. The belts are looped in horizontal layers in this box, so that the supply of ammunition is not disturbed by movement of the rifle in train or elevation. The average number of cartridges in a belt is 250; belts are also made to contain 100 and 500 cartridges each.

The automatic operation of the gun is effected by means of the pressure of the powder gases in the barrel. There is a small vent in the bottom of the barrel near the muzzle, opening downward from the bore. This vent is closed by a small piston which projects up into it vertically from a gas cylinder. The gas cylinder is attached to the under side of the barrel of the gun and surrounds the gas vent. Fitting into the gas cylinder is a gas lever and the end of this gas lever is pivoted to the piston which plugs up the vent. The gas lever swings downward and to the rear in a vertical plane from the gun barrel, through an arc of approximately 90°, being actuated by the downward motion of the piston to which it is attached. The operation of the gas lever actuates the breech mechanism, which operates in turn to eject the empty cartridge case, load a new cartridge, and fire it, assuming that pressure is on the trigger.

After the feed belt has been entered in the breech of the gun, the gas lever is operated by hand all the way down and to the rear; this actuates the breech mechanism to bring a loaded cartridge on to the carrier; the lever is now released and a spring causes it to swing up and back into position, transferring the loaded cartridge from the carrier to the gun barrel and closing the vent near the muzzle. The upward motion of the gas lever also cocks the hammer and closes and locks the breech.

On pulling the trigger the cartridge is discharged. After the bullet has passed the gas vent and just before its exit from the muzzle, the powder gases behind the bullet ex-

pand through the vent, force the pistol down, which operates through the gas cylinder to force the gas lever down and to the rear, in the same manner as if operated by hand.

The gas lever operates as before, ejecting the empty cartridge case through its connection with the breech mechanism and transferring a new cartridge to the carrier. **On its return to normal position the gas lever actuates the breech mechanism to load a new cartridge, cock the piece, and close the breech ready for another firing.**

If, now, the trigger, instead of being released after the first cartridge was fired, was held back, pressure being maintained continuously, the second cartridge would fire as soon as the breech closed, and the operation would continue successively and automatically as long as the pressure on the trigger was maintained and the ammunition properly fed.

A **safety lock is provided** which securely locks the hammer and prevents it from striking the firing-pin. It is used only when a loaded cartridge is in the chamber and you are "standing by" to fire.

The hammer is also used as a piston for an air pump, which forces a strong jet of air into the chamber and through the barrel, removing all residue and unburnt powder after each shot is fired, and after the empty cartridge case has been ejected.

The barrel of the gun is exceptionally heavy and strong, so that it will not heat too quickly from rapid firing, and also that its accuracy will not be affected by the vibration incident to rapid firing.

The barrel is detachable, and two barrels are supplied with each gun issued. If the barrel becomes exceptionally hot from firing, it can be replaced.

The **mount of the gun,** in which it rests and moves in elevation, and in train and by means of which it is mounted on either the field carriage or the tripod stand, consists of two principal parts, the **yoke** and the **saddle.**

The **yoke corresponds to the carriage of a broadside gun.** Its lower part is in the form of a spindle which fits into a

socket in the top of the tripod and permits movement in train.

The **saddle corresponds to the slide of a broadside mount.** It is pivoted in the yoke by means of an axis bolt so as to swing freely in a vertical plane. **The gun rests in the saddle,** being fixed in position in it and moving with it in elevation. **Elevation is effected** by a worm gear which engages the teeth of an arc attached to the saddle. Operation of the worm gear is caused by a hand wheel. This elevates and depresses the gun.

OPERATION

The following description of the operation of the automatic gun assumes the reader to be in actual charge of the gun and conducting and responsible for the firing.

ATTACH CARTRIDGE BOX in position on left side of gun, at breech casing.

TO LOAD: Push brass tip of cartridge belt through opening above ammunition box and draw it out on the other side as far as possible. **Let go of the belt. Operate the gas lever** downward and to the rear as far as it will go. This transfers first loaded cartridge from the belt to the carrier. **Release gas lever.** As the lever returns to position, it actuates the breech mechanism to transfer the loaded cartridge from the carrier to the chamber, cocks the piece, and locks the breech mechanism. **The gun is now ready to fire.**

TO FIRE: **Press the trigger and hold it back.** The first cartridge will fire and the gas from the explosion will actuate the automatic mechanism of the gun to eject the fired cartridge and load a new cartridge, the operation continuing automatically and successively while the finger is holding back the trigger and until the ammunition belt is empty.

SUSPEND FIRING: **Release the trigger.** Push **safety catch** from position of **fire** to position of **safe.** To suspend firing as here described the **barrel of the gun must not be too hot**; that is, hot enough to fire the loaded cartridge in the chamber by virtue of its heat. When the barrel is hot enough for this, you must **cease firing.**

TO RESUME FIRING from position of suspend firing: Push safety catch back to position of **fire** from position of **safe.** If necessary to bring new loaded cartridge into chamber, **operate gas lever downward and back once** for this purpose. **Press trigger.**

CEASE FIRING: Release the trigger. Push forward the knurled head on the right side of the gun near the belt exit, and **draw out the loaded belt to the left. Operate the gas lever once by hand,** as in loading, in order to eject the loaded cartridge that remains in the chamber of the gun.

MISSFIRES AND HANGFIRES: If, during a string of shots, the gun should suddenly stop firing, wait a moment before doing anything. As a rule the trouble is a **hangfire and the gun will commence firing again in a second or so if the pressure is kept on the trigger.** If the gun does not commence firing again within several seconds, you probably have a **missfire caused by a defective cartridge.** In this case, operate the gas lever by hand as in loading, having previously released the trigger. This operation of the gas lever will **eject the unexploded or defective cartridge and load a new one. Now press trigger again, and if piece resumes firing, you had a missfire due to a poor cartridge.** If the gun still does not resume firing, some part of the gun mechanism is at fault.

STOPPAGE FROM ANY CAUSE: Whether the stoppage occurs from the jamming of a cartridge, missfire, or breaking of a part of the gun; **whatever the cause, operate the gas lever once by hand before making any effort to free the mechanism. If the stoppage occurs while the lever is in mid-position, push it down and backward, never forward.** This will generally free the mechanism, unless a broken part stops it. If it still does not operate, you must remove the ammunition belt (to the left); also any cartridges from the chamber and examine for breakages. The faulty part is removed and replaced as quickly as possible.

In **case of jamming** due to failure of the mechanism to eject a fired cartridge case which has become wedged in the bore, operate the gas lever downward and hold it down, letting the next live cartridge descend into bottom position,

past the chamber. Still holding the gas lever down in order to keep breech open, remove cartridge case with knife or by means of a rammer from the muzzle end.

CARE AND MAINTENANCE

The gun in proper working order **fires 400 shots per minute,** and to consistently maintain this rate of fire it is absolutely necessary that the gun and its mechanism be kept in perfect operating condition at all times.

After every firing dismount the mechanism completely, thoroughly clean and oil it, after having washed each piece of the mechanism in warm soap and water solution. Examine every part carefully before reassembling to see that each is in proper condition.

After reassembling, place belt of dummy cartridges in gun and operate lever several times by hand to see that mechanism is in condition for proper firing.

After rapid firing never permit a loaded cartridge to remain in the chamber any longer than is necessary, as the heat of the gun barrel will fire it.

If gun is very hot, after continuous firing for three or four minutes, release the ammunition belt and draw it out an inch or two to the left, then work the gas lever, emptying the chamber.

Before using a loaded belt in a gun, look to see if cartridges are well home in the loops and that their bases are perfectly even.

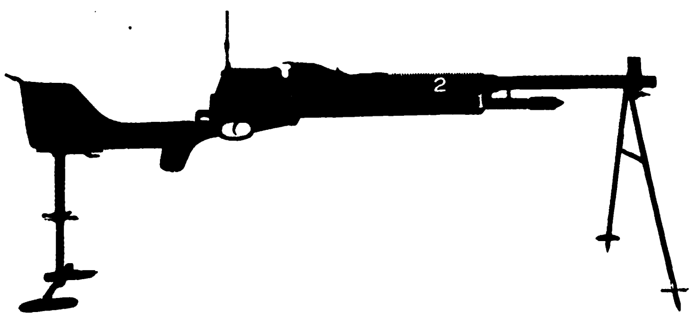
When exposed to weather or to spray from seaway, keep piece well covered and dismount mechanism daily to clean and oil.

When use of gun is not contemplated, as in Peace times, keep well oiled, and stowed away.

AUTOMATIC MACHINE-RIFLE, MARK II (BENET-MERCIE)

This rifle in its general principle of operation is similar to the Colt Automatic Gun; that is, to the extent that auto-

COLT AUTOMATIC RIFLE — ON TRIPOD STAND
1, Gas lever; 2, Ammunition box.



BENET-MERCIE AUTOMATIC MACHINE RIFLE
1, Actuator; 2, Radiator (air-cooled).

matic firing in each case is brought about by powder gas in the rifle bore from the previous cartridge fired.

The principal parts of the rifle are a **single barrel**; **receiver**; **guard**; and **stock**, all rigidly assembled in practically the same manner as in a small-arm rifle. Situated in the **receiver** and having a **reciprocating motion in it**, parallel to and below the barrel, is an **actuator** that performs the same functions that the gas lever performs in the Colt Gun. In the bottom of the barrel, near the muzzle of the rifle, is a **gas vent** or **gas nozzle.** Gases passing through this nozzle, as a bullet leaves the muzzle, operate on the **actuator,** forcing it to the rear in its guides. In its movement to the rear, the actuator operates mechanism to eject the fired cartridge case and load and fire a new one, as was done in the Colt Gun. The **actuator** is returned to position by an **actuator spring** which it compresses in its motion to the rear, and which expands as soon as the powder gas pressure is removed from the other or forward end of the actuator.

OPERATION

TO LOAD: Open the breech by means of the **cocking-handle** at the breech which is somewhat similar to the bolt of a small-arm rifle. **This opens the breech and holds the breech block back; it also draws the actuator to the rear in its guides and holds it there.**

The feed strip is now entered in the receptacle for it in the breech mechanism. **Unlike the Colt Gun the ammunition is fed on steel clips, carrying thirty cartridges apiece and feeding left to right.** When the last cartridge on a clip fires, the whole clip is automatically ejected to the right and a new one is entered by hand, from the left.

When the clip or feed strip has been entered, it is automatically locked in position and the gun is **ready to fire.**

TO FIRE: Press the trigger. This releases the actuator, which is propelled forward by its spring, carrying with it the breech block; the breech block in closing pushes a cartridge from the feed strip into the rifle chamber, the breech is

locked, and the firing-pin moves forward against the primer of the cartridge, firing the rifle.

When the bullet, in its passage through the bore, passes the gas nozzle, powder gases issue through the nozzle, and operate on the actuator, which is forced to the rear. In its motion to the rear, the actuator operates the breech mechanism to eject the empty cartridge case and advance the feed strip sufficiently to bring the next cartridge in the rear of the chamber. As the pressure is maintained on the trigger constantly, the operation is repeated continuously while the ammunition is properly fed.

This rifle, instead of having a safety lock, has three marks or notches on the cocking handle. These are labeled A, R, S, and represent automatic, repetition or single shot, and safe. When the cocking-handle is turned to the position marked A, the firing mechanism operates automatically; at R only one shot can be fired at a time, and at S the piece cannot be fired.

The mount is entirely different from the Colt Gun, consisting of a support at the butt end which can be raised and lowered for elevation and two forked legs or supports under the muzzle. The piece can be mounted on a field carriage for use by landing parties, or can be carried in the hand and used as a small arm from a comparatively prone position on the ground.

The precautions to be observed in the use of the gun, and the care to be given it, are essentially the same as those enumerated for the Colt Gun, except, where the term gas lever is used, the cocking-bolt should be substituted for the Automatic Machine Rifle.

LEWIS AUTOMATIC MACHINE RIFLE

In its manner of automatic operation, this rifle follows the others in its principle.

The essential point of difference is that this gun uses a circular magazine, carrying 47 cartridges, instead of a web belt or a wire clip.

The automatic operation is performed by the trapping of a portion of the powder gases formed by the explosion of each cartridge.

These gases follow the bullet down the gun barrel and a part of them escape through a port in the bottom of the barrel near the muzzle. After they are cleansed, the gases pass into a gas cylinder on the under side of the barrel, where they operate on a piston, driving it to the rear.

As this piston moves to the rear, a rack on its lower side engages a small pinion wheel, rotating it, and winding up a small circular spring inside of it. The gases having expended their energy, the spring unwinds and the energy in it rotates the pinion wheel back to its original position, and drives the piston forward.

The operation of the piston rod operates the gun automatically to eject empty cartridge cases, load new cartridges and fire them, if pressure is maintained on the trigger.

LOADING: A full magazine is placed on the magazine post at the breech of the rifle, and the **charging-handle** is drawn back.

Pressure on the trigger will now fire the gun.

Single shots may be fired by pressing and rapidly releasing the trigger.

Chapter XXV

BATTLE DRILLS

CLEAR SHIP FOR ACTION — GENERAL QUARTERS — TORPEDO DEFENSE STATIONS — BATTLE STATIONS

The primary purpose of all battle drills is to train the ship's personnel in their exact duties, to be performed in action, and in preparing to go into action.

The drills should be realistic, assuming in every case that actual engagement is contemplated. If these drills are carried out properly and in the proper spirit by the ship's officers and men, when the time of actual engagement does arrive, every man will know his station and his duties; there will be no confusion nor friction. Everything will go off smoothly and like clockwork.

CLEAR SHIP FOR ACTION

As soon as it is anticipated that the ship is about to be engaged in battle, the Commanding Officer will give the word to "**Clear Ship for Action.**"

By clearing ship for action we mean generally, **to make all necessary preparations for battle**; **to remove all wooden articles**, etc., that might cause a fire, if struck by enemy shells; **to remove all metal gear about decks** that is not a part of the ship's structure, in order to protect not only the gear, but also the crew from steel splinters and parts of it in case it should be struck by enemy shell; **and to remove all instruments, etc., to a safe place** below the armor belt of the ship.

SIGNAL: Boatswain's mates pipe, "**All hands clear ship for action.**"

DETAIL DUTIES AND PRECAUTIONS. — The following list covers general preparations for battle. In drills these preparations are not feasible to execute and are not made. It is required, however, that certain men be charged with the responsibility of performing them in time of battle, and that these men be thoroughly familiar with the action to be taken.

Prepare for full power on engines. Have full head of steam on all boilers.

Serve out lunches to crew. **Haul galley fires** and keep out during engagement.

Stow in torpedo rooms detonators and dry primers for use in torpedoes. Others shall be stowed in safe compartments well below the water line so as to be available for use and be also in a safe place.

Prepare to load torpedoes.

Release prisoners from brig and give them battle stations.

Throw overboard unnecessary inflammable oils, paints, and liquids.

The remaining list of preparations must be made at every drill to "Clear Ship for Action."

Rig light life lines on deck which, if carried away, will not foul propeller screws. Lay down and secure davits and stanchions flat on deck. (The necessary short stanchions should be so fitted on rails and bridges that they can be kept shipped and not interfere with gun fire.)

Fill recoil-cylinders of all guns.

Prepare dynamos, air compressors, and fire and bilge pumps for service, and start those necessary.

Connect up and test out all fire-control and ship-control communications and instruments.

Test out and prepare for action all firing circuits and air blasts.

Connect up and lead out fire hose. (Secure hose so as to be clear of blast of guns.)

Rig all necessary blast screens. Secure searchlights against blast.

Throw in battle circuits. Throw out all circuits not required for action.

Prepare auxiliary lighting arrangements — electric flashes, oil lamps, etc.

Rig battle signal stations (radio and flag).

Rig repair stations; prepare collision mat.

Rig dressing stations and prepare transportation for wounded.

Supply first-aid packages at all guns and stations.

Fill gun-tubs.

Supply drinking water to all gun crews and where necessary elsewhere.

See in proper places all necessary spare parts. Supply ray filters and material for wiping off sights.

Prepare auxiliary steering and ship-handling stations.

Shut steam not needed off all unprotected leads. Prepare to operate boiler stop and safety valves from outside boiler compartments.

Wet down weather decks and plug scuppers. Put water in boats and lash canvas about them. Prevents fires.

See auxiliary gear for sustaining combat ready for use. Appliances for group or independent control of guns at hand. Ammunition supply and transportation gear rigged.

Rig torpedo firing director and test torpedo firing circuit and special signals and lines of communication to torpedo room.

Provide grapnels for clearing the screws.

Secure anchors, unbend chains, and pay below into chain lockers below decks. (While on soundings keep one chain bent.)

Stow life preservers in convenient but protected places.

Close the watertight doors and hatches designated to be sealed during action. Close battle ports. At night screen all lights. (Attention is called to the necessity for not interrupting the means of access or of communication to the various parts of the ship.)

Unship and secure the ventilators and ladders that interfere with the battery.

Stowage shall be assigned to the following in such a place as will leave free passage for the ship's company and still afford protection from gun fire:

Navigational instruments.

Coaling gear.

Mess and galley gear.

Sick bay mattresses not needed, bags, hammocks, ditty boxes, and cots.

Gunnery training gear.

Diving gear.

Field guns.

Wash deck gear.

All other loose gear.

Before battle men shall bathe and shift into clean underclothes.

Supply ammunition.

Have small arms and ammunition ready for serving out.

Masthead the battle ensigns and make all final preparations for battle.

STRIP SHIP

This is not exactly a drill. It is a preliminary step to clearing ship for action.

A ship is "stripped" when war is impending. During war, ships are continuously "stripped", meaning that all gear and equipment not absolutely necessary is sent ashore.

To give an idea of the articles sent ashore, the following partial list is given:

Saluting guns.

Officers' dress uniforms.

Trunks.

All wooden chests, bookcases, etc.

All unnecessary canvas.

Presentation silver service, trophies, etc.

All inflammable stores, except those necessary for operation of the ship.

All unnecessary wooden furniture, rugs, curtains, etc.

GENERAL QUARTERS

"GENERAL QUARTERS" calls the entire ship's company to battle stations, primarily to man the main battery and fire-control stations, etc., for a long-range engagement. Secondarily, it calls the ship's company to stations for repelling a torpedo boat attack.

At General Quarters every gun in the ship should be manned and prepared to fire; every fire-control station should also be manned and every preparation made for battle.

SIGNALS:

General Alarm Gongs.

"General Quarters" on the bugle.

"General Quarters" reported at all terminals of the ship's interior communication system.

GENERAL DUTIES:

Man battery and take battle stations.

Load torpedoes.

Connect fire hose.

Stand by manifolds and valves.

Stand by cut-out switches and switchboards.

Test out all gear.

All those preparations and dispositions enumerated under **clear ship for action** which are necessary for the control and service of the battery shall be carried out to the extent necessary to use the battery.

Every officer and man must occupy his battle station at general quarters. Fleet working parties and ship's work and boating must give way to the General Quarters routine.

General Quarters drill is held at least once a day at the present time on all naval vessels.

Officers and Chief Petty Officers wear automatic pistols.

REPORTS TO BE MADE:

"**Ready.**" (To be made over fire-control and interior communication systems.)

Gun divisions, fire-control division, and torpedo division report to chief fire control.

Ship control, radio and signal crews report to navigating officer.

Engineering department, medical department, and repair crews report to central station.

Chief fire control, navigating officer, and central station report to executive.

Executive reports to captain.

The " ready " report must be made promptly by the head of each group or division, and as soon as all necessary preparations have been made.

CONDUCT OF THE DRILL

The purpose of the drill is to work out definite battle exercises. Problems in fire control are worked out; sights are set, ranges and deflections being sent over the fire-control system. Thorough preparation should be made for every General Quarters exercise, and a definite program should be drawn up and followed at this drill, during which casualties to personnel and material should be simulated.

The training of units of the battle organization and gun crews should not be attempted at General Quarters except to simulate casualties to personnel and material. Gun crews and other units are expected to be expert before the ship goes into action, and they should be brought to thorough proficiency before seriously taking up the problems of General Quarters.

SECURE:

Signals for secure:

" Secure " on the bugle.

" Secure " over the interior communication system.

Reports:

" Secure." (To be made in person.)

After secure, divisions assemble at quarters. Senior present in each division reports to head of department.

Heads of departments report to executive.

Executive reports to captain.

TORPEDO DEFENSE QUARTERS

"TORPEDO DEFENSE QUARTERS" calls the entire ship's company to "torpedo defense stations", primarily to repel a torpedo boat or submarine attack; taking such gun and control stations as have been previously assigned.

Secondarily, it calls the ship's company to man the main battery.

At torpedo defense quarters, the main battery should be manned in addition to the broadside battery. It is not likely that the main battery will be brought into action, but it is ready, if the action should develop into a general engagement.

SIGNALS:

General alarm gongs.

"**Torpedo defense quarters**" on the bugle.

"**Torpedo defense quarters**" **over interior communication system.**

GENERAL DUTIES:

Before sunset.

Man battery and take torpedo defense stations; man all searchlights.

Load torpedoes.

Connect fire hose.

Stand by manifolds and valves.

Stand by cut-out switches and switchboards.

Test out all gear and searchlights.

Screen all lights.

Complete preparations necessary for the control and service of the battery.

When all "**ready**" reports are in, "set the watch"; watch below disperse to designated parts of the ship close to their night battle stations.

After sunset the ship should be standing by for night action; as all duties should have been attended to before sunset, and as all stations should be occupied by the battle watch, it remains only for the watch below to take stations for torpedo defense. Half the ship's company, then, would be continually at

stations, standing by for a torpedo attack. The other half is " below " ready to take stations on the signal.

Every officer and man must occupy his battle station at torpedo defense quarters.

Torpedo Defense Stations are manned at least twice a day at the present time on all naval vessels.

Officers and responsible petty officers, as at " General Quarters ", wear automatic pistols.

REPORTS TO BE MADE:

" **Ready.**" (To be made over fire-control and interior communication systems.)

Gun divisions, fire-control division, and torpedo division report to chief fire control.

Ship control, radio and signal crews report to navigating officer.

Engineering department, medical department, and repair crews report to central station.

Chief fire control, navigating officer, and central station report to executive.

Executive reports to captain.

CONDUCT OF THE DRILL

At a torpedo defense drill, actual conditions are simulated as far as possible. Definite problems are solved. Often a steamer or motor boat is sent out as a target for the training and pointing of guns; for the exercise of the group fire-control system; and for a practical drill with the searchlights.

SECURE:

Signals for secure:

" **Secure** " on the bugle.

" **Secure** " **over the interior communication system.**

Reports:

" Secure." (To be made in person.)

After secure, divisions assemble at quarters. Senior present in each division reports to head of department.

Heads of departments report to executive officers.
Executive reports to captain.

BATTLE STATIONS

What is known as the ship's " Battle Station and Quarter Bill " assigns to each officer, man, or group of men on the ship a definite station and definite duties to be occupied and performed whenever " General Quarters " or " Torpedo Defense Quarters " are sounded.

The principal stations are briefly outlined, with a summarization of the duties of the group coming under each head of department.

Captain, conning tower; relief, executive.

Executive, secondary ship control station; in direct communication with the captain.

Gunnery officer, chief fire control (Groups I and II); relief, first lieutenant.

Navigating officer, primary ship control station (Group III); relief, designated by the captain.

Engineering officer, engine rooms (Group IV); relief, next in rank in the engineering department.

First lieutenant, central station (Group V); relief, designated by the captain.

Medical officer, primary dressing station (Group VI); relief, next in rank in the medical department.

Pay officer, station and relief to be designated by the captain.

GROUP I

(Under Gunnery Officer)

Fire control.

Determination of the initial range during the " approach."

Control of fire under all conditions of battle, viz.:

Successive stations in event of casualties.

Direction and control of fire on one target.

Division and control on two targets on the same side.

Division and control on two targets on opposite sides.
Direction and control of torpedo defense battery on attacking destroyers during a day action.
Independent turret control.
On attacking destroyers at night.
Casualties and procedure.
Secondary searchlight locations.

GROUP II

(Under Gunnery Officer)

Armament and ammunition.
Guns and torpedoes — Service and Firing.
Ammunition supply.
Gun crews in reserve.
Gun and torpedo casualties. — Means of continuing fire.
Ordnance repair crew.

GROUP III

(Under Navigating Officer)

Ship control.
Battle signaling.
Successive ship control stations.
Successive steering stations; methods of steering.
Interior communication.

GROUP IV

(Under Chief Engineer)

Motive machinery and auxiliaries.
Engines, boilers, and auxiliaries.
Casualties and procedure.
Engineer force in reserve.
Engineer repair crew.

GROUP V

(*Under First Lieutenant*)

Repairs.

Fire and collision in action.

Watertight doors closed and those not to be closed.

Procedure in emergencies, such as fouling screws; masts, one or both, shot away; taking disabled ship in tow, etc.

The repair crews will be available for fighting fire, operating valves, shoring bulkheads, stopping leaks, clearing wreckage, repairing electric leads, etc. Portables and tools will be supplied at the repair stations. Tools shall include wrenches, sledges, lamps, crowbars, tackles, shores, pipe cutters, gear for repairing electric leads and apparatus, etc. Stowage at the repair stations should be provided for this gear. The repair crews shall include the rescue breathing apparatus details.

GROUP VI

(*Under Medical Officer*)

Aid to wounded.

Primary and secondary dressing stations.

Stretchermen details.

General instructions.

First appliances include shell wound dressings and tourniquets. Solutions for the smoke-inflamed eyes of the men at the guns, and dressings for burns and scalds in engine and fire rooms, plainly labeled, should be accessible to those stations.

Chapter XXVI

THE GUNNERY OFFICER OF A SHIP

GUN DIVISIONAL OFFICERS — THEIR DUTIES

The following extracts from Naval Regulations and Instructions outline the general duties and responsibilities of the ship's gunnery officer, and also of all other officers having charge of gun or turret divisions; torpedo or fire-control stations.

THE GUNNERY OFFICER OF A SHIP

(Extract from Naval Regulations)

2501. **Personality.** (1) **The gunnery officer of a ship is the officer detailed by the department to have supervision over and be responsible for the entire ordnance equipment, and is the head of the gunnery department of the ship.** The gunnery officer shall, if practicable, be the line officer next in rank to the executive. He shall make such inspections and perform such duties at drills and exercises as the commanding officer may direct.

(2) **If detached, disabled, etc.** If detached, absent, disabled, placed under arrest, suspended from duty, or otherwise rendered incapable of performing the duties of his office, his duties shall devolve upon the line officer next below him in rank attached to and on board of the ship (exclusive of such as may be restricted to the performance of engineering duty only); except that, when such absence or disability is temporary and of short duration only, the commanding officer may, at his discretion, authorize his duties to be carried on in his absence from duty by the

officers, warrant officers, and other subordinates directly under him in the performance of his regular duties, without diverting the line officer next in rank from his regular duties in order to assume those of ordnance officer.

(3) Aboard ships other than first rates, and other than second rates having turret guns, to which no regular gunnery officer is attached, the executive officer shall perform the duties of gunnery officer.

(4) Aboard smaller ships, where the executive officer is regularly assigned to perform the duties of the navigating officer, all the regular duties of the gunnery officer shall be performed by the senior watch officer in addition to his regular duties.

2502. **General duties.** (1) The gunnery officer shall assist the executive officer in carrying out the provisions of Article R 2203 (4) **especially in connection with fire control and the drill, exercise, and efficiency of the armament as a whole**; and to this end he shall have, subject to the executive officer, the necessary authority over all officers connected with the armament.

(2) **He shall have charge of all material and articles of outfit pertaining to the Bureau of Ordnance**, that have been issued for use by the supply officer of the ship, except as provided for in Article R 2621 (2). [Art. I. 2311 (6).]

2503. **Armament.** (1) **The gunnery officer shall be held responsible for the efficiency of the armament and of all appurtenances connected therewith; and for the cleanliness and good condition of all magazines, shell-rooms, and ordnance workshops, and of all ordnance store-rooms not turned over to the supply officer of the ship.**

(2) **Explosives. He shall supervise and be responsible for the proper stowage and care of all explosives on board ship**, and shall personally make such inspections, examinations, and tests thereof as may be prescribed by the department.

2504. **When ship is placed out of commission.** (1) When the ship is placed out of commission, the gunnery officer, ordnance gunner, chief gunner's mate, and yeoman shall

not be detached or transferred until the battery and entire ordnance equipment of the vessel have been inspected by a special board, nor until the ordnance supplies in charge of the gunnery officer have been satisfactorily accounted for and surveys covering shortages have been held and approved. [Art. R 3912 (1).]

(2) When a gunnery officer is relieved, his order of detachment shall not be delivered until he has made a detailed inspection of the armament for which he is responsible in company with his successor, and has turned over to such successor all orders and instructions relating thereto.

2505. **Acting as executive officer.** When acting as executive officer during a temporary absence or disability of the latter, the gunnery officer shall endeavor to have the work of the ship carried on in all respects as it would be if the executive officer were on duty.

(*Extract from Naval Instructions*)

1701. **When fitting out.** (1) When fitting out, the gunnery officer shall make a careful inspection of the battery and its appurtenances, and of all arms, equipments, and other material belonging to the gunnery department; of the magazines and shell-rooms, the passages, light boxes, flood cocks, outlet and overflow pipes, hose, hoisting and transporting gear, and all other appurtenances connected with the stowage, care, preservation, and service of the ammunition of the ship.

(2) **He shall during his inspection ascertain whether the magazines and shell-rooms are dry and their linings tight; the means for flooding and draining efficient and in order; the arrangement for stowage complete and ample; the lenses clean, carefully set, and without fracture; the lighting apparatus in order, well ventilated, ample in power, and capable of burning at least four hours; and the means for supplying ammunition to the battery safe, efficient, and ample.**

(3) When the magazines and shell-rooms are ready for the

ammunition, and he is familiar with all their appurtenances, he shall report the fact to the executive officer.

(5) Should he discover any defects or deficiencies, he shall immediately make a detailed written report of the facts to the commanding officer.

1702. **Duty in regard to ordnance stores.** (1) The gunnery officer shall perform similar duties in connection with the outfit and supplies under his charge as are prescribed for the first lieutenant in I, Chapter 13.

1703. **Officers' revolvers.** Upon the detachment of officers the gunnery officer shall require the return to him of revolvers and other ordnance stores which have been loaned to them for their personal use.

1704. **In battle the gunnery officer shall be stationed in central control of the battery in direct communication with the captain. An officer junior to him shall be detailed as his assistant in fire-control duties, with a view to becoming his relief if occasion arise.**

1705. When the officer of the deck is required to take part in drills and exercises, the gunnery officer may be designated by the commanding officer to take the deck. He may relieve the officer of the deck at any time as a matter of accommodation.

1706. The gunnery officer shall not absent himself from the ship except as provided for in Article R 3708.

GUN DIVISIONAL OFFICERS

(*Extract from Naval Regulations*)

Section 2. — Officers in Charge of Gun, Fire Control, Torpedo, and Powder Divisions

2621. **Assignment to divisions.** (1) **Officers shall be assigned by the commanding officer to gun, fire-control, torpedo, and powder divisions in such manner as, in his judgment, will most conduce to the efficiency of the ship as a whole.** [Art. I. 2501 (I).]

(2) **Responsibility for material.** They shall be responsible

for the care and preservation of all ordnance material, stores, supplies, and articles of outfit issued to their divisions.

(3) **To keep fully informed concerning the armament.** They shall keep themselves fully informed of all regulations, instructions, and technical details concerning the care, preservation, and manipulation of the armament of the ship and its appurtenances, and the training of enlisted men. They shall scrupulously observe every prescribed and necessary precaution for safety.

2622. **Officers commanding divisions shall personally instruct and exercise their divisions at all prescribed drills.** They shall also, under their immediate supervision, afford every opportunity to the junior officers and petty officers to become proficient in exercising and handling men. [Art. I. 2502 (2).]

2624. **Fighting efficiency of divisions.** Officers commanding divisions shall endeavor to bring the divisions under their command to the highest possible state of fighting efficiency.

2625. **Lower deck officer.** (1) The captain shall assign an officer whose battle station makes this detail practicable, who shall, during quarters, in all matters requiring the exercise of military command, have charge of the berth deck and all below it, exclusive of the engine and fire room spaces. Should a fire occur during action within the limits of his command, he shall take charge of all hose and other means at hand for extinguishing it, and close the magazines and shell-rooms, unless the fire is remote from them and the urgency for supply of ammunition great. He must be prepared to close instantly such watertight doors, valves, and gates as will tend to check the spreading of the fire, or to keep the ship afloat should her hull be pierced.

(2) He shall bear in mind that he occupies a most responsible position, and that, while he should make to the commanding officer all reports possible, the safety of the ship may, in times of emergency, depend upon his acting immediately, before any instruction can reach him.

(*Extract from Naval Instructions*)

Section 2. — Officers Commanding Divisions

1821. **Instructions and supervision over guns, and arms.** (1) Officers commanding divisions shall during exercise follow the directions laid down in the official instructions and take the necessary precautions to prevent accidents.

(2) They shall see that the men of their divisions, in accordance with the prescribed duties of each, keep the guns, arms, and all their appurtenances clean and in order.

Chapter XXVII

INFANTRY

(Close Order)

RECRUIT — SQUAD — COMPANY — BATTALION — DRILL UNDER ARMS

No effort is made in these pages to cover the subject of **Infantry drill in close order formation** in detail, nor is it anticipated that these pages will in any way take the place of the detailed instructions on the subject that are to be found in the " **Landing Force and Small Arms Instructions** " issued by the Navy Department. It is aimed merely to include the essentials of the subject, treated and explained perhaps from a somewhat different angle, in this book, in order that all items and subjects that might in any way be included under the head of " **Ordnance and Gunnery** " will be together here for ready reference and handy use.

THE RECRUIT

The **POSITION OF ATTENTION** is the first lesson to be taught to the new recruit and should be well fixed in the mind of every one in the Naval Service:

(1) **Heels on the same line and together.**

(2) **Feet** turned out equally, forming **an angle of about 60° with each other.**

(3) Knees straight.

(4) **Body erect** on hips, inclined slightly forward. **Shoulders square.**

(5) Arms and hands hanging naturally; backs of hands outward; **thumbs along seams of trousers**; elbows near body.

(6) **Head erect and square to the front**; chin drawn in; **eyes front.**

The **FACINGS** are used not only by one recruit acting singly or individually, but more often by each member of a squad, company, battalion, or other unit.

RIGHT, FACE !

Raise the right heel and left toe and face 90° to the right, turning on the left heel, and at the same time placing the right foot by the side of the left.

If this movement is executed as a member, or file, of a squad or larger unit it will be done at the command of the officer or petty officer in charge. In this case the command "**Right**" **is called the preparatory command** and simply conveys the meaning to "stand by." "**Face**" is the **command of execution** and is given sharply. On hearing it, each man in the unit faces sharply to the right as described and again stands at attention.

LEFT, FACE ! is similarly executed, the facing being made 90° to the left **and being executed on the left heel, the same as right face.**

ABOUT, FACE !

At the preparatory command, "**About**", carry the toe of the right foot **eight inches to the rear** and **three inches to the left of the left heel,** without changing the position of the left foot. At the command of execution, "**Face**", turn toward the right upon the left heel and right toe, face to the rear, and re-place the right heel by the side of the left.

TO EXECUTE A FACING TO THE RIGHT OR LEFT IN MARCHING, and to continue the march, turn on the ball of either foot, and step off with the other foot in the new direction.

RIGHT OR LEFT, HALF, FACE ! is executed the same as right or left face, except that the change of direction is only 45 degrees.

PARADE, REST ! At the command of execution, "**Rest**", **carry the right foot six inches straight to the rear**; bend the left knee slightly; **keep right knee stiff**; **clasp hands naturally in front of body, left hand on top**; left thumb clasped by thumb and forefinger of right hand; **preserve silence** and steadiness in ranks.

ATTENTION ! Resume position of attention smartly.

MANUAL OF ARMS

The position of the rifle and the various methods of carrying the rifle will be briefly described at this time. The drilling of a company in the manual of arms will be discussed later in greater detail.

ORDER, ARMS !

The butt of the rifle rests evenly on the ground. The arms hang naturally, elbows near the body, the **right hand holding the rifle between thumb and fingers, first two fingers in front, the others in the rear.** The barrel of the rifle is to the rear, with the **toe of the rifle touching and on a line with the toe of the right foot.**

Whenever falling into ranks with a rifle, keep the piece at the order.

When standing in ranks at attention, keep the piece at the order always, unless an order calling for a change of manual be given.

When marching with a rifle in any position, always bring it to the order, without command, immediately after coming to a halt.

PORT, ARMS !

The rifle is diagonally across the front of the body, resting well up in front of the chest. The right hand grasps the small of the stock, palm down; the left grasps the piece at its center or balance, palm up, with thumb around piece and the hand outside of the strap. The piece slopes upward to the left, **the muzzle bisecting the angle between the head or**

neck, and the left shoulder — the barrel is up. The right forearm projects horizontally across the front of the body; the left forearm rests against the body. **The left hand is in line with the chin and left shoulder. The piece is in a vertical plane parallel to the front.**

The position of **PORT ARMS can be assumed FROM THE POSITION OF ORDER** by grasping the piece firmly with the fingers while at the order, and without changing the position of the fingers — then raising the piece with the right hand and **throwing it diagonally across the body,** grasping it smartly with both hands in the position described for port. **At the preparatory command, don't lower the right shoulder, and lean over toward the right while waiting for the command of execution. Keep the shoulders square always.**

SHOULDER, ARMS !

The **rifle is on the right shoulder.** The rifle barrel is uppermost. The trigger and trigger guard are just below the hollow of the shoulder. The heel of the butt of the piece is between the first and second fingers of the right hand; thumb and other fingers being closed around the stock. **The right elbow is held close in to the body, sticking in to the ribs, while the forearm projects out horizontally. If the forearm is held strictly horizontally and the right hand is kept in line or directly in front of the elbow, the piece will be carried in the proper position, being both fore and aft and at the proper angle.**

In coming to the SHOULDER FROM ORDER ARMS, the position of port must be gone through as a distinct, intermediary step. Being at the order, then, at the command "**shoulder, arms !**" the position of port is first assumed in one count. Then to come to the position of shoulder, on the second count, the piece is carried over and placed on the right shoulder, the right hand being dropped to the butt and taking a firm grasp on it, and helping to carry the rifle to the shoulder. **The left hand is placed on the small of the stock, fingers outstretched, left forearm extending across in**

front of the body in the position of " rifle salute." The left hand steadies the piece, and on the third count, the left hand is dropped smartly back to the side.

From PORT TO SHOULDER is gone through as described in the last part of the preceding paragraph.

SLOPE, ARMS !

The **rifle** is **carried on the left shoulder.** Otherwise its position is identical with that described for " **shoulder, arms !** "

In **coming to the SLOPE FROM ORDER ARMS, the position of port must be gone through as a distinct, intermediary step.** Being at the order then, at the command " **slope, arms !** " the position of port is first assumed in one count. Then to come to the position of slope, on the second count the piece is carried over and placed on the left shoulder, the left hand being dropped to the butt and taking a firm grasp on it, helping to carry the rifle to the left shoulder. The right hand is placed on the small of the stock, fingers outstretched, right forearm extending across in front of the body in the position of " rifle salute." The right hand steadies the piece, and on the third count it is dropped smartly back to the side.

From PORT TO SLOPE is gone through as described in the latter part of the preceding paragraph.

PRESENT, ARMS !

The rifle is held vertically in front of the center of the body, barrel to the rear. The left hand holds the piece, grasping it at its center or balance, the thumb extending along the left side of the barrel. **The left forearm is horizontal** and rests against the body. The right hand grasps the small of the stock. The eye is on a level with the upper band of the rifle.

From **ORDER TO PRESENT** is executed direct, and is the only position of the manual that can be taken without first executing **port arms** as an intermediary step. It is executed in two counts. At the first count, without changing the position

of the fingers of the right hand, carry the piece to the front of the center of the body with the right hand, barrel to the rear and vertical. Grasp it now with the left hand at the balance of the piece, thumb extended along barrel and forearm horizontal and resting against the body. At the second count, grasp the small of the stock with the right hand, bringing it down smartly, slapping the stock with the flat of the fingers.

TO RETURN TO POSITION OF ORDER FROM EITHER PORT OR PRESENT ARMS.

Command — Order, Arms !

Executed in two counts. **At the first count,** let go the piece with the right hand and re-grasp it with all the fingers of the right hand just above the lower band, back of the hand to the right; let go with the left hand, and carry the piece with the right to the right side, barrel to the rear. **The execution of the foregoing should be practically simultaneous, amounting to dropping the piece down to the right side.** With the right hand near the thigh, hold the piece with the butt about three inches above the ground. **The left forearm extends across the front of the body, the fingers extended and resting on the piece to steady it.** The palm of the hand is inclined downward. **Hold the piece in this fashion momentarily, making a distinct move of it. At count two,** lower the piece **gently** to the ground with the right hand, drop the left hand quickly to the side and resume the position of **order arms.**

FROM SHOULDER TO ORDER ARMS.

Command — Order, Arms !

Executed in three counts, coming through the position of port. **At the first count,** the butt of the rifle is pressed down quickly with the right hand, **the fingers grasping the butt tightly to control the rifle.** The piece is now thrown diagonally across the body, dropping into both hands in the position of **port.** At **counts two** and **three,** execute as described for coming to the order from port arms.

PARADE, REST ! (Under Arms.)

At the command of execution "**Rest,**" carry the right foot six inches straight to the rear; bend left knee slightly; keep shoulders square to the front; **at the same time carry the muzzle of the piece in front of the center of the body, barrel to the left,** and the piece turning on the heel of the butt; grasp with the left hand just below the upper stacking swivel; **place the right hand below and against the left. The entire movement should be executed in one motion and "very quickly."**

ATTENTION ! The position of "**Order, arms**" is resumed in one motion, turning the piece on the heel of the butt and dropping the left hand quickly by the side.

TRAIL, ARMS !

At the command of execution, grasp the rifle with all the fingers of the right hand without changing its position; raise the piece slightly, right arm slightly bent at the elbow; **incline the muzzle forward so that the barrel makes an angle of about 30 degrees with the perpendicular.**

The position of "trail" may be taken from any other position in the same general manner as in coming to the "order."

It is used when carrying a rifle indoors; and on covered decks aboard ship, when the recruit is acting singly.

In company, the "trail" is used when marching "at ease." It is rarely used at other times; only under special conditions, and then for short periods.

SECURE, ARMS !

The piece is held with the right hand at the balance, barrel down; the muzzle slopes down and to the front; right hand is supported against the right hip, thumb along barrel; upper arm against stock.

Used only in inclement weather, to protect the piece.

The foregoing covers the principal positions and evolutions. Any others grow out of those described, or are executed similarly. For the details of these reference is made to the "**Landing Force and Small Arms Instructions.**"

GENERAL RULES

The following statements apply to the execution of the manual in general and should be carefully kept in mind.

In any drill at the manual, the position of port arms is gone through as an intermediate step between any other two positions, excepting only the present from the order and vice versa.

In going from shoulder to slope arms or vice versa, keep the head erect. Don't move the head out of the way of the rifle. Move the rifle around the head. This applies also to any movement involving the position of shoulder or slope.

At order arms, keep the toe of the piece alongside the toe of the right foot. Be sure the butt of your rifle is properly aligned, not several inches to the front or rear, etc.

Execute every move in the manual distinctly and with a snap. Often a company executing the manual properly looks better than other companies better drilled, but with a sloppy manual.

In coming to order arms, never attempt to land the butt of the rifle on a street pavement, floor, etc. with a crash, for the cheap, spectacular effect it gives. Lower the rifle easily and gently to the ground. Otherwise the butt of your rifle will soon split.

The cadence, or time of execution of the manual, is the same as the quick step in infantry, 120 steps to the minute. Every effort must be made to keep this cadence, so that any execution of the manual in company will be together and in cadence. In foregoing explanations, the counts necessary to properly complete each move were given. Recruits should count to themselves until practice makes this unnecessary.

SALUTING WITH AND WITHOUT ARMS

Every man and officer in the Service salutes a superior commissioned or warrant officer on passing, except under special rules operating on board ship, and on some shore stations, when a superior is saluted only the first time you see him in the morning; after that the salute being given

only when personally addressed by the officer or when addressing him.

The salute is always given with the right hand. The left is used if the right is engaged.

In saluting raise the right hand smartly till the tip of the forefinger touches the lower part of the cap, above the right eye. **The thumb and fingers are extended and joined, palm to the left and inclined slightly downward.** The upper arm extends straight out from the shoulder. The forearm inclines upward, **wrist and hand straight**, fingers touching cap. When the salute is returned, the hand is dropped smartly back to the side.

In company with other men in ranks, as at an inspection by a commanding officer, the salute is given at the command — **RIGHT HAND, SALUTE!** — the hand being brought to salute at the command of execution, " **Salute.**" The hand is kept at the cap, until the command "**Two**", when it is returned smartly to the side.

Officers and men, when saluting, **turn the head and eyes toward the person saluted.**

The **salute is rendered at 6 paces before passing**, or being passed by, an officer, unless the nearest point reached be greater than 6 paces and not more than 30 paces, in which case, salute at the point nearest the officer.

Keep the hand at the cap until the salute is returned or until it is certain that it has not been observed, when return the hand quickly to the side.

Never pass a superior officer on the street (overtaking) without saluting and requesting " **By your leave, Sir.**"

Never quibble about saluting. When in doubt, salute.

RIFLE SALUTES. At shoulder or slope — Carry left or right hand, as case may be, smartly to the small of the stock of the rifle, forearm horizontal across body, thumb and fingers extended, forefinger against the piece and palm of hand inclining downward. When the salute is returned, drop the hand quickly back to the side.

At order arms — Carry the left hand smartly to the right side, forearm horizontal, or nearly so, thumb and fingers

extended and joined, forefinger against the piece, and palm of hand inclining downward. When the salute is returned, drop the hand quickly back to the side.

At trail arms — Same as at order arms.

The same regulations govern the rifle salutes as cover hand salutes.

Officers not under arms return the rifle salute with a hand salute.

Officers under arms carry a drawn sword.

A sentry in saluting executes "present, arms." This is returned by the hand salute.

In squads, companies, detachments, or other bodies of men, only the senior officer, or petty officer in charge, salutes an officer in passing.

The rifle salutes are given by individual men with arms, out of ranks.

THE SQUAD

A Squad consists of a petty officer and eight men. If the petty officer is ever absent, the next senior man takes charge.

The squad is the smallest unit into which the men are grouped for purposes of discipline, drill, battle, etc.

TO SIZE THE SQUAD.

The men are arranged according to height, in column and at facing distance, tallest man at the head of the column. Have men count off by two's.

Squad leader commands.

In two ranks form squads, March! At "**march**", the command of execution, the first man faces to the left; the second man places himself in the rear rank, covering the first at a distance of 36 inches. The other men close in, in quick time, and form alternately, number one's in front rank and number two's in rear rank, as explained for the first two. Each man faces to the left upon arriving at his proper place; **then dresses to the right,** preserving a slight touch of elbows. At the command, "**Front**", of the squad leader, each man snaps his head and eyes to the front.

STEPS AND MARCHINGS

QUICK TIME is the regulation step and cadence of normal marching in an Infantry organization.

The **length of the step is 30 inches** from heel to heel.

The **time or cadence** of marching is at the rate of **120 steps per minute.**

DOUBLE TIME amounts practically to a quick trot. The step and cadence are both slightly increased over the quick time.

The **length of the step is 36 inches,** from heel to heel.

The **time or cadence** is at the rate of **180 steps per minute.**

The usual difficulty with double time marching is that step and cadence are hurried until the unit is almost on a dead run, with consequent disorganization. **Don't hurry the cadence or increase the step. Keep the same dress and relative position in ranks as when marching at the quick time.**

During the double time, the **forearms are carried up, extending along the waist line in a horizontal position.** The fingers are closed and the arms are swung naturally.

HALF STEP is, as the name implies, just half the length of a step in quick time.

The **length of the step is 15 inches.**

The **cadence is the same as quick time, full step** — 120 to the minute.

SIDE STEP is from left to right or vice versa, termed "**Right, step**" and "**Left, step**", respectively.

It is used only to move the unit a short distance to either side in correcting its position, etc. **It is never used to move a company through any considerable distance to one side or the other. It can be given only from a position of "halt."**

The length of the step is 10 inches.

The **cadence is that of quick time — 120 steps per minute.**

The general tendency is to hurry the cadence in the side step. Give the step by calling, "one, two, three, four, one", etc., until this is overcome.

BACK STEP is executed by each man in the unit stepping backward straight to the rear. **It is not used for any but very short distances.** The command is "**Backward, March!**"

The length of the step is 15 inches.

The **cadence is that of quick time or 120 steps per minute.**

Back step is the same as half step, only executed in the reverse direction.

TO MARCH FORWARD, or to the front in quick time from position of halt.

Command — Forward, March!

At the preparatory command, "**Forward**", the weight of the body is thrown on the right leg, **the left knee being kept straight.** At the command of execution, "**march,**" the left foot is moved smartly 30 inches to the front; at the same time throw the weight of the body forward and plant the left foot without shock. Now advance the right foot in the same manner; continue the march.

Always step off with the left foot.

DOUBLE TIME FROM QUICK TIME.

Command — Double time, March!

At command of execution, "**march**", given as either foot (usually the left) strikes the ground, **take one step in quick time**; then step off in double time as described for double time.

TO RESUME QUICK TIME FROM DOUBLE TIME.

Command — Quick time, March!

At the command of execution, "**march**", given as either foot (usually the left) strikes the ground, **advance and plant the other foot in double time**; resume the quick time, dropping the hands by the sides.

MARK TIME.

Command — Mark time, march!

At the command of execution, "**march,**" given while marching and at the instant either foot is coming to the ground, take up the same quick time cadence without gaining

ground, by alternately advancing each foot about half its length and bringing it back on line with the other. **In marking time, keep the knees stiff, carrying each leg forward in turn from the hip.** In taking up the mark time from a halt, start off with the left foot as in marching forward.

TO HALT.

Command — Squad (or Company), Halt!

At the command of execution, "**halt**", given as either foot (usually the left) strikes the ground, **advance and plant the other foot; place the foot in the rear by the side of the other.** The only divergence from this rule is in coming to a halt from the **side step.** In this case the "**halt,**" is given when the feet are together; one more step to the right or left is then taken; the other foot brought up alongside and the halt made in the usual two counts.

The **halt** is given from whatever step the unit may be executing: — quick time, half step, back step, etc. It is customary when a company or squad is marching at double time to first resume quick time — then halt. This preserves better the order of the unit.

Remember that the halt is executed in two counts. After the command halt advance the other foot one step. This is count one. Bring up the foot from the rear. This is count two.

TO MARCH TO THE REAR.

Command — To the rear, March!

At the command of execution, "**march**", given as the **right foot strikes the ground,** advance and plant the left foot; then, turning on the balls of both feet, face to the **right about,** and immediately **step off with the left foot. Don't confuse the foregoing with "backward, march."**

TO MARCH BY THE FLANK.

Command — By the right flank, March!

At the command, "**march**", given as the **right foot** strikes the ground, advance and plant the left foot — **then face to the**

right in marching, and step off in the new **direction with the** right foot.

If executing, **By the left Flank,** the march is given as the **left** foot strikes the ground, **and** the step-off, **after facing to** the **left** in marching, is with the **left foot. This move is executed either from the march or mark time.**

CHANGE STEP.

Command — change step, March!

At the command, "**march**", given as the **right foot** strikes the ground, advance and plant the left foot; **now plant the toe of the right foot near the heel of the left and step off again with the left foot.**

If the command should be given as the left foot strikes the ground, the change step is similarly executed.

FORMATION AND MANEUVERING OF THE SQUAD

The squad is sized up in two ranks, tallest man on the right of each rank, as has been previously described.

The **ranks of a squad are thirty-six inches apart. This distance must be maintained at all times, marching or at a halt.**

By the term "**file**" we mean **two men, the front-rank man and the rear-rank man covering him.** The front rank man is the **file-leader. Cover in file** means to take your position directly in the rear of the man ahead of you. A **blank file** is a vacant place left in the rear rank. **If there should ever be an absentee from the front rank of a squad, the rear file steps up and fills it without any command, immediately on the squad falling in.**

If a blank file in the rear rank is necessary, it should always be the place of **number three. Two blank files** would leave vacant the **places of numbers two and three.** The absence of numbers one or four, rear rank, would cause their places to be filled immediately, without command, by number two or three as the case might be. These men side step into the blank or vacant end file.

TO FORM THE SQUAD.

Command — Fall In!

This command is given by the petty officer of the squad, who has previously taken his position **three paces in front and center** of the position in which he wishes the squad to fall in.

Immediately on the command, the **members of the squad fall in, in their proper places at attention.**

Command — Count Off!

At this command by the squad petty officer, **each man, front and rear rank, snaps his head and eyes to the right (except the right file, number one men).** Beginning on the right, the men in each rank **count off**; counting, one, two three, four, in succession; each man turning head and eyes to the front as he counts. **The count by each man should be made only loud enough for the man on his left to hear, not shouted. The men of each rank should endeavor to count together. In counting, each man turns head and eyes to the front, not clear over from right to left, as is frequently done.**

The squad is now formed.

With the squad under arms there are additions to this procedure. This will be discussed in detail in connection with company maneuvers and to cover it here would only cause repetition.

OBLIQUE MARCH.

Command — Right (or Left) Oblique, March!

At the command of execution, "**march**", given while the squad is marching forward, either at quick or at double time, **each man steps off in a direction 45 degrees to the right of his original front. He preserves his relative position, keeping his shoulders parallel to those both of the man ahead of him, and of the man on his right. The ranks of the squad are to remain parallel to their original front.** The men are to cover in file. As a result of this command, the whole squad moves obliquely to a new position.

Forward, March! given by the squad leader causes the squad to resume quick time in the original direction, each

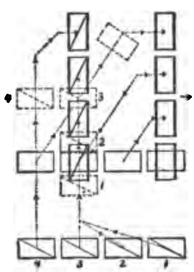
man again executing a half face or turn through 45 degrees, this time to the left. The execution of "**forward march**" from the oblique, should see the squad in proper alignment in ranks and covering in file.

"**Halt**" given by the squad leader while the squad is marching obliquely, causes it to halt, **but facing to the front** in the same position as when falling in.

The **use of the oblique movements is mainly in avoiding obstructions**, wagons, etc. in street marching. It is used in any case where you want to shift the unit a short distance over from one side to the other.

SQUAD RIGHT (OR LEFT), MARCH!

This **move is called the turn on the fixed pivot**, inasmuch as the pivot man marks time on the turning point or pivot after making his turn, and continues "marking time" **until** the rest of his squad are all lined up properly with him, but facing in the new direction. The above command is given by the squad petty officer. At the command of execution, "**march**", **number one, front rank**, faces 90 degrees to the right and **marks time. Numbers two, three, and four, front rank, oblique to the right**, take up their new position abreast of number one **and mark time. Number three, rear rank, moves straight to the front** until in the rear of his file leader when he faces right and marks time. Numbers two and one, rear rank, follow number three in column in this order; 2, 1, facing right when covering their file leaders. Number four, rear rank, marches three paces straight to the front and covers his file leader, placing himself abreast of number three, rear rank.



SQUAD RIGHT

Fixed pivot—step off on fifth count

As the men come on the new line, each glances toward the marching flank (Number one, each rank), while marking time, and as the last man arrives on the line, both ranks execute — "**Forward, March,**" — without command.

In carrying out — **squad, right** — the turn is made in **four counts. On the fifth count, all men of both ranks should be ready and step off together, marching forward,** in proper alignment.

HALTING FROM SQUAD RIGHT (OR LEFT) AND WITHOUT ADVANCING

Command — Squad right (left), March! Squad, Halt!

As explained in the preceding paragraph, when a squad has executed squad right or left in four counts, each man of the squad steps off together on the fifth count in the new direction, **without further command.**

If it is desired to **halt** the squad on the new line facing in the new direction, **instead of having it take up the — forward, march,** — this can be effected by the squad leader giving the preparatory command — " **squad** " — **immediately following** the execution command, **march,** of **squads right.** The command **squad, must immediately follow** the command, **march.** The **halt** can be given when the squad is marking time on the new line.

Example: Squad right, march! **Squad.** At the command " **march** " the squad executes squad right as described. The command " **squad** " immediately following, signifies to the squad that it marks time facing in the new direction and without making any advance. When the entire squad has made the turn and is marking time, the command " **halt** " brings them to the position of attention.

SQUAD RIGHT (OR LEFT) ABOUT, MARCH!

This command **calls for a complete revolution of the squad on a fixed pivot.** Squad right about, uses number one, front rank as the pivot, and left about uses number four.

The **best explanation of this move is that it consists of executing squad right (or left) twice.**

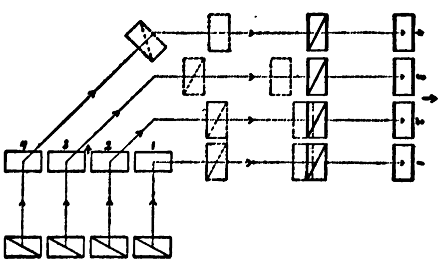
Instead of four counts, as in squad right, the right or left about is **executed in eight counts,** all men stepping off in the new (the reverse) direction on the **ninth count.**

The squad is halted, if desired, immediately following the right or left about, and before advancing to the front, in the same manner as described for squad right or left.

SQUAD, RIGHT (OR LEFT) TURN, MARCH!

This **move is called the turn on the moving pivot. Distinguish it from squad right, previously described, and which calls for the turn on a fixed pivot.** The term moving pivot is given, inasmuch as the pivot man, instead of marking time as he makes his turn, **steps off in the new direction at a half step,** maintaining the half step until the rest of the rank are abreast of him and all going forward at the half step, dressing toward the pivot, **when all step off together with the quick time, full step, without command.**

The above command is given by the squad petty officer. **The move is executed by each rank in succession,** instead of by the whole squad together. At the command of execution, "**march**", the **pivot man of the front rank** (number one in a turn to the right) **faces to the right in marching, and takes up the half step.** Every other man in the front rank (numbers two, three, four) go right oblique until each uncovers the man preceding him, when he **executes a second right oblique and goes forward, all at the full step, quick time,** until abreast of his right file, when he takes up the half-step, to accommodate himself to the step of the man to his right. Each man as he comes on the new line glances toward the marching flank, keeping the alignment. As the last man arrives on the line, **the whole rank steps off together with a full step, without further command. The rear rank executes the turn when on the ground on which the front**



SQUAD RIGHT TURN
Moving pivot; turn made at half step; step off, full step, on fifth count

rank turned, and in the same manner as described for the front rank.

SQUAD, RIGHT (OR LEFT) HALF TURN, MARCH!

This move is done also on the **moving pivot** and is **executed in exactly the same manner as described for the right** (or left) **turn**, except the turn of the direction of march of the squad is only 45 degrees to the right or left instead of 90 degrees. It is half of a full turn.

DIFFERENCE BETWEEN MOVING AND FIXED PIVOTS IN SQUAD TURNINGS.

Squad right (or **left**), **March!** **is executed on the fixed pivot.**

Squad right (or **left**) **turn, March!** **is executed on the moving pivot.**

In squad right, the right file, front **rank,** is the pivot man and **after facing 90 degrees to the right, marks time,** until the whole squad is aligned in the new direction, when he steps off with a full step.

In the **right turn** the same man, right file, front rank, is the pivot, but, **after facing 90 degrees to the right he steps off at a half step,** until the rest of the front rank are aligned with him, when he steps off with a full step.

The **squad right** is executed **either from a halt or a march.**

The **right turn** should be executed **only when marching forward or when marking time.** Never from a halt unless special circumstances demand it.

The **squad right is executed by the entire squad together.**

The **right turn is executed by each rank of a squad in succession.**

Both of these evolutions are used largely in connection with company movements. In this connection, the **squad right** (squads right, for the company) finds its principal use in changing the formation **from a company front or line to a column of squads** and the reverse. The **squad, right turn** finds its principal use in connection with the company evolution, **column right, when in column of squads**; in

this case each squad, or each rank of each squad, executing the right turn in succession.

TO MARCH THE SQUAD IN SINGLE FILE.

Command — Single file, March!

At the command of execution, "**march**", assuming that the squad is marching forward in double rank or column of twos **with the right file of the squad leading**, each **rear rank man places himself in the front rank, in front of his leading file or own front rank man.** If the squad is marching in the same manner with the **left file, or number four men leading,** each **rear** rank man places himself in the front **rank, but in the rear of his leading file.**

MARCHING IN SINGLE FILE, TO REFORM THE DOUBLE RANK.

Command — Form double rank, March!

At the command of execution, "**march**", each rear rank man places himself abreast his leading file or file-leader, and both ranks close in to facing distance, the men in the rear increasing the pace until closed up, if necessary.

SQUAD EVOLUTIONS FOR PHYSICAL DRILL, ETC.

TO TAKE INTERVALS (To right or left).

Command — To the right (or left) **4 paces, take intervals, March!**

At the first, **the preparatory command,** the rear rank steps back together to four paces distance from the front rank. At the command of execution, "**march**", **every man in the squad faces to the right and the leading man in each rank steps off**; when the leading men have advanced four full paces, the next two men step off following them at the designated four pace intervals; the other remaining men step off in succession in the same manner, until there is a four-pace interval between every file in the company.

Command — Squad, Halt!

The command "**halt**" is given when all men have their proper intervals. At this command each man halts, and **faces to the front.**

The above can be executed by units larger than the squad and in the same manner.

To accommodate conditions and space, the interval between men can be made larger or smaller as desired, by replacing the four paces given in the command with the number of paces desired. Where no number of paces is given, it is assumed as four.

TO ASSEMBLE FROM THE ABOVE.

Command — To the right (or left), assemble, March!

At the command of execution, "**march**", the **front rank man on the right stands fast**, and the rear rank man closes in, covering him at 36 inches distance. **All other men face to the right and close in**, to the close order formation, by moving to their proper places in ranks **by the shortest possible route**; then face to the front and stand at attention.

TO TAKE DISTANCES (To the Front).

(In line at a halt and counted off.)

Command — Front, 4 paces, take distance, March!

At the command of execution, "**march**", number one of the front rank moves straight to the front. When he has advanced the required distance, in this case four paces, number 2 steps off. The other men of the squad, numbers 3 and 4, front rank and 1, 2, 3, 4, rear rank, move in the order named, straight to the front, each stepping off so as to follow the preceding man at the designated distance.

Command — Squad, Halt!

This is given when all men have their proper distances. At it each man "**halts**" **and stands at attention.**

In case more than one squad is in line, each squad executes the movement as above, together, and each rank of numbers guides on its right number.

Any desired distance can be specified instead of four paces, but where **none** is designated, four paces will be understood.

TO ASSEMBLE (To the front).

Command — Assemble, March!

Number 1 of the front rank, of each **squad, if more than** one, stands fast; **all** other men of each **squad move directly forward, halting in succession in their proper places in line.**

TO ASSEMBLE (To the Rear).

Command — To the rear, assemble, March!

Number 4, rear rank, of each squad if more than one, stands fast. All other men of each squad, **about face at the first (preparatory) command.** At the command of execution, "**march**", they step off to the rear, taking their proper places in ranks, then facing front and standing at attention.

Assembling to the rear has the advantage of reforming the squad in the original position or location.

THE COMPANY

The **company** is the unit for military drill and tactics. It is divided into two equal parts, called **sections**, the **right section being the first, and the left being the second section.**

The company consists or is made up of **six full squads, totaling 48 men.** In addition, there are 3 **officers** and **6 petty officers.** The 3 officers consist of a **company commander** and **two chiefs of sections**, one each for the first and second sections of the company. The **six petty officers** are assigned **one to each squad**, the **first** and **second p. os.** being in addition the **right and left guides** of the company respectively.

POSITIONS OF OFFICERS AND PETTY OFFICERS

IN COMPANY FRONT OR LINE.

Company Commander is 3 paces in front of the center of the company.

Each Chief of Section is 2 paces in the rear of the center of his section.

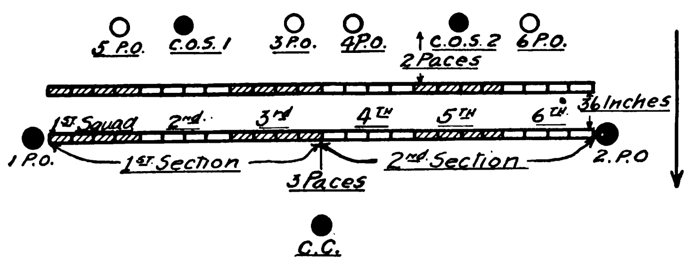
The 1 **petty officer** is in the front rank of the company on the right of the first section; **he is the right guide of the company and also of the first section.** He is the p. o. of the first squad. He is not covered by any rear rank man.

The 2 **p. o.** is in the front rank of the company on the left of the second section; **he is the left guide of the company and also of the second section.** He is the p. o. of the sixth or left squad. He is not covered by any rear rank man.

The 3 **p. o.** is 2 paces behind the rear rank in the line of file-closers. His position in the line of file-closers is to the rear of the third squad (the left squad of the first section). He is the p. o. of the third squad; **he is also the left guide of the first section when in section formation.**

The 4 **p. o.** is in the line of file-closers. His position in the line of file-closers is 2 paces to the rear of the rear rank of the fourth squad (the right squad of the second section). He is the p. o. of the fourth squad; **he is also the right guide of the second section when in section formation.**

The 5 **p. o.** is in the line of file-closers, 2 paces to the rear of the rear rank of the first squad of the first section. He is the p. o. of the second squad of the company and first section.



Company Front or Company in Line

Full company, 6 squads, 48 men, 6 petty officers; 36 inches between ranks, 1 man to 18 inches of front; c. c., 3 paces front and center of co.; line of file-closers, 2 paces rear of rear rank.

The 6 **p. o.** is in the line of file-closers, 2 paces to the rear of the rear rank of the sixth squad of the company. **He is the p. o. of the fifth squad,** the p. o. of the sixth squad being the left guide of the company.

The line of file-closers is dressed 2 paces in the rear of the rear rank of the company.

IN COLUMN OF SQUADS.

Company Commander is at the head of the company and on the flank on which the guide has been established. He marches abreast the leading guide, usually the first petty officer of the company.

Chiefs of Sections are in the line of file-closers, on the side of the company opposite to the company commander: The c. o. s. (1) marches opposite the rear rank of the second squad (the middle squad of the first section). The c. o. s. (2) marches opposite the rear rank of the fifth squad (the middle squad of the second section).

The **first petty officer** is the right guide of the company. When the right squad of the company is leading; that is when the company is marching in the proper formation, the 1 p. o. is the guide. **He is 36 inches in front of the front rank of the first squad. He marches on the side or flank of the company on which the guide has been established** by the company commander. The c. c. marches abreast the 1 p. o.

The **2 p. o.** is the left guide of the company. His position is 36 inches in the rear of the rear rank of the last squad. He marches on the flank on which the guide has been established; **on the same flank as the 1 p. o. (right guide).** When the left squad of the company leads the column or when the company is said to be inverted, the left guide is the leading guide of the company and the right guide becomes temporarily the rear guide.

The **3, 4, 5, 6 p. os.** each march opposite the rear rank of the same squad that they have their position in the rear of when in company front. They all march in the line of file-closers, which is 2 paces from the flank of the company.

The c. c. and the guides are on the side of the company or column on which the guide has been established. The line of file-closers is always on the other side.

TO FORM THE COMPANY

Assembly on the bugle is the signal for the company to fall into ranks.

The **first petty officer** takes a position 3 paces in front of where he wishes the center of the company to be formed, facing the company.

Command — Fall in!

Each man falls in in his own particular place in the company, this place having been previously assigned when the company was **sized.**

Assuming the company to be under arms (equipped with rifles and bayonets), the men **fall in with their rifles** at the **position of order arms.**

All men being in ranks, or the **assembly having ceased** on the bugle, the **1 p. o.** commands — **Port arms!** With the company at the **Port,** the **1 p. o.** calls the roll. As each man answers " **here** " to his name as called, he comes to the **order arms.**

COUNTING OFF.

Command — Count off!

This is given by the **1 p. o.** after the roll has been called or the company mustered. At the command, each man, front and rear rank, snaps his head and eyes to the right; then, beginning on the right of the company each man, in front and rear ranks, counts one, two, three, four; one, two, three, four, and so on to the left, in succession, until the whole company has counted off. **Each man as he counts his number turns his head and eyes sharply to the front.** The general tendency is to turn the head over to the left when counting off and for each man to shout his number into the ear of the man next to him. This is to be avoided. **The head is turned to the front and the number is spoken loud enough, only, for the man to the left to hear it distinctly.** The men of both ranks aim to count off together, each rear rank man counting his number together with his front rank man. This enables both ranks to finish their counting off at the same time.

REARRANGEMENT OF THE COMPANY.

The counting off process establishes the number of squads in the company for that particular drill. There are usually absentees for one reason or another that break up the order of a company and cause a slight rearrangement at each drill. The **1 p. o. effects this rearrangement.** If the count showed an incomplete squad on the left of the company, it is usual to fill up this squad by taking the **number three's** from the rear rank of every other squad, making the vacated places **blank files. Number two's** rear rank may also be made blank files, where necessary. In case there are a sufficient number of squads already in the company front, the odd numbers on the left of the line can be used to fill up possible blank files in other squads, or a limited number may be placed in the line of file-closers. The best rule to follow is common sense. Use your judgment, remembering that it is **always desirable to have a full, six squad company, even with some blank files.** Next it is desirable to have an **even number of squads so that the sections are of equal size.** Where it is necessary to have five squads, the **right section is the larger one,** having the odd squad.

OPEN AND CLOSE CHAMBERS OF RIFLES.

The company has now been formed and is at attention with rifles in the position of order arms. The 1 p. o. now causes the opening and closing of the chambers of the rifles to insure no loaded cartridges being in the rifles during the drill. It is always possible that a loaded cartridge may have been left in a rifle from a previous drill and if so it may be fired during a subsequent drill. Opening the chamber of the rifle would eject it and is thus merely a safety precaution. It is mandatory to open and close rifle chambers before and after every drill with rifles.

Command — by 1 p. o.: **Port, Arms!**

The company comes to the position of **port** at the command of execution.

Command — Open, Chambers!

At the preparatory command, **open**, the **safety lock is turned to the left**, if the piece has been locked; also the **magazine cut-off is turned up** if in any other position. The **bolt handle of the rifle** is now grasped **with the thumb and forefinger of the right hand**. At the command of execution, **chambers**, turn the bolt handle up, draw bolt back smartly and glance at the chamber and magazine of the rifle to see that they are empty. **Keep right hand on bolt handle.**

Command — Close, Chambers!

At preparatory command, **close**, keep right hand on bolt handle and **stand by**. At command of execution, **chambers**, push the bolt forward, turn the bolt handle down, **pull the trigger**, for the piece has been cocked by the operation of the bolt, turn the magazine cut-off down and carry the right hand back to the small of the stock, resuming the position of port, arms.

Command — Order, Arms!

Company comes back to the order.

REPORT TO COMPANY COMMANDER.

When the company is again at order arms, at attention, the **1 p. o.** executes an **about face**, salutes the company commander, who has previously placed himself 6 paces in front of the center of the company and facing it, and reports —**Sir, all present or accounted for**—or the names of unauthorized absentees. The 1 p. o. in making the report gives the rifle salute with his rifle at the order. If unarmed, he would give the hand salute. The **1 p. o.** now returns to his post as right guide, without command. He does not return by the shortest line, but by straight marchings, making every turn and facing distinctly.

The c. c. after receiving the report of the 1 p. o. returns the salute by hand first, then draws his sword and assumes command of the company.

The chiefs of sections take their posts and draw swords with the **c. c.** as soon as the 1 p. o. makes his report. The company while being formed is in command of the 1 p. o. Both chiefs of sections, being senior to the 1 p. o. do not fall

in while the 1 p. o. has charge, but wait until the c. c. assumes command.

SIZING THE COMPANY.

With an entirely new complement of men to be organized in military units, the first step is to divide them into companies and to size them properly in their companies. Nothing looks worse than a company improperly sized or not sized at all.

The company according to Navy Drill regulations **is sized with the tallest men on the right and left of the company, the height gradually decreasing from each side toward the center, the shortest men being in the center of the company. Both ranks are to be sized as nearly alike as possible.**

No rules for effecting this sizing are laid down, but the following scheme, based on the method of sizing the squad, previously described, has been found by the writer in practice to serve the purpose very well.

Line up the entire company in column at facing distance, tallest man on the right, decreasing to the shortest man on the left. Company officers rearrange men as desired.

When all are in proper position, command — **In two ranks, form company, march!** Executing this as described for the squad, your company is brought into company front, with the tallest men on the right of each rank, decreasing to the shortest on the left.

Now take each rank separately. Repeating the maneuver with the front rank, you have the **right section properly sized**, tall men on the right, short on the left. Now form the rear rank into the second or left section. Have rear rank **right face**, then go column right (or left) twice; this turns the rank around so that the tallest man is on the left and the shortest on the right, although the rank is still parallel to its old front. Now form this section in two ranks to the left, similarly as the right section was formed in two ranks to the right. This completes the formation of the **left** section, tall men on the left and short men on the right. The section is now aligned with the right section to reform the company.

The company is dressed with tall men at each end and short men in the center (both ranks practically alike). Men are cautioned to fall in in these same positions thereafter.

RIGHT (OR LEFT), DRESS!

Before giving the command, **the company commander places himself in prolongation of the front rank, two paces from the guide or flank of the company and facing the flank on which the dress is to be taken.** He then commands as above. At the command of execution, **dress,** every man, front and rear ranks, **snaps head and eyes to the right,** excepting only the right guide of the company and number one, rear rank. It is on these two men that the dress or alignment is established. Simultaneously with the turning of head and eyes to the right, each man moves slightly forward or backward as necessary to correct the alignment. **Men close in toward the point of dress,** in this case, the right flank of the company, **preserving a slight touch of elbows.** The c. c. corrects the alignment as he deems necessary and when it is satisfactory to him, he marches to a position **three paces in front of the right flank of his company, executes a left face** and commands, **front,** at which each man **snaps head and eyes to the front.** The c. c. now takes his position in the front and center of his company.

Left dress is executed in the same manner, except that the dress is taken on the left flank of the company.

GUIDE, RIGHT! (OR LEFT) — MARCHING.

This command is given **only when marching** to designate the flank on which the dress or alignment is to be maintained.

Men preserve their intervals from the side of the guide as given, yielding to pressure from that side and resisting pressure from the opposite direction; they recover intervals, if lost, by gradually opening out or closing in; they recover alignment by slightly lengthening or shortening the step.

The **guide is always right, unless otherwise given** by the company commander.

In column of squads the guide is always toward the flank

on which the c. c. is marching and away from the line of file-closers.

In any unit, the file-closers keep their dress in the same position as has been outlined for them.

In turning the company such as in company right or right turn, **the guide is toward the pivot while the turn is being made,** reverting back to the original guide as soon as the turn has been completed.

EYES, RIGHT! (OR LEFT) — MARCHING.

At this command by the c. c., **eyes,** being the preparatory, and **right,** the command of execution, each man, front and rear rank, executes eyes right in marching, turning the head as in right dress, so as to bring the left eye in a line about two inches to the right of the center of the body. The head and eyes are kept in this position until the c. c.'s command, "front," when head and eyes are again brought to the front, the march continuing.

Company officers, including the c. c., carrying swords, execute "present" with the sword at the command of execution, **right,** and return the sword to the position of **carry** at the command, **front.**

Eyes right is executed as a rule in ceremonies, reviews, etc., when the company is "passing in review" before high officials, dignitaries, etc. In this case **eyes right** is executed six paces before the reviewing officer is reached and **front** is given six paces past the reviewing party.

AT EASE! — HALTED.

This command by the c. c., given when the company is halted, permits the men to relax from the position of attention. **They must, however, maintain one foot in position,** ready to form ranks immediately on the command — **Attention. They must also preserve silence and stand steady.**

AT REST! — HALTED.

This command given by the c. c., when the company is halted, permits the men to relax from the position of attention

and also in all other respects is the same as that described for **at ease, except that it is not required that the men preserve silence or immobility — merely that they keep one foot in position. It does not mean that any one may become boisterous,** — only that they may speak in ordinary conversational tones and turn their heads, etc.

FALL OUT!

Given at a halt, this permits the men to leave the ranks, **but they must remain in the immediate vicinity**, ready to resume at quick notice their positions.

FALL IN!

At this command, following the command, **Fall Out,** previously described, the men resume their position in ranks **at attention.**

AT EASE, MARCH! (On the march.)

This command, by the c. c., should be given when the company is in column of squads formation. The men are permitted to carry their pieces at will, **but keeping the muzzles elevated.** The step is broken, **but the relative position in ranks is maintained and the men keep silence.** Officers carry their swords at will or in the scabbards.

Company, Attention — resumes the march, at attention.

ROUTE STEP, MARCH!

This is executed in identically the same manner as described for, **At ease**, except that the men are **permitted to talk.**

Company, Attention — resumes the march, at attention.

If the company should be halted while marching, either **route step**, or **at ease**, the men would **stand at ease.**

The company is marched **route step** or **at ease**, through very heavy roads, over ice, and across bridges, flimsy structures, etc., where the tramp of a number of feet coming down at the same time might further weaken it to a breaking point, thus endangering the men.

OPEN RANKS, MARCH!

Command (c. c.) — **Open ranks!**

Officers carry swords (including chiefs of sections).

Right and Left Guides of company each step three paces straight to the rear, to mark the line on which the rear rank is to dress when opened out.

Cs. of S. advance to the right and left of the front rank, respectively, taking the places vacated by the guides, swords being retained at the carry.

File-closers (remaining) step back three paces in the rear of the new line established by the guides.

Alignment of guides is verified by c. c. in person. He then places himself three paces in front and two paces to the right of his company and facing to the left.

Command (c. c.) — **March!**

Cs. of S. each move forward three paces, face toward the center in marching, and, upon arriving at their posts, each in front of the center of his own section, halt, face to the front, and dress to the right.

Front rank executes — **right dress.**

Rear rank goes — **backward, march, halting** a little in the rear of the line established by the guides; then **dresses to right** on line of guides.

File-closers — Dress right.

In the moves or operations enumerated after each of the foregoing commands (by c. c.) the executions are as nearly simultaneous as is possible.

The right guide corrects the alignment of the rear rank.

The c. c. corrects the alignment of the cs. of s., and of the front rank; he verifies that of the rear rank and line of file-closers. Officers and p. os. turn head and eyes to the front as soon as their alignment is verified. Alignment being satisfactory, c. c. takes position, three paces in front of right flank of company and facing left.

Command (c. c.) — **Front!**

Guides resume posts.

Front and rear rank men turn heads and eyes to the front.

C. c. resumes position in front and center of company, between cs. of s., sword at the carry.

CLOSE RANKS, MARCH!

Command (c. c.) — **Close ranks!**

Cs. of s. carry swords.

Command (c. c.) — **March!**

Cs. of s. face outward and resume their posts in rear of their sections, marching back in a direction at first parallel to the front of the company.

Rear rank marches forward two paces, closing in to within 36 inches from front rank, each man covering his file-leader.

File-closers close in to within two paces of rear rank.

C. c. takes position in front of company.

Open ranks is the position of a company during its inspection by any officer.

Aboard ship, where space is limited, **open ranks** is used to have a division ready for inspection by a commanding officer. In this case, the section leaders are not present nor is the division under arms. The only other point of difference from the move as described, is that after the ranks have been opened, the front rank executes an **about face** on command of the divisional officer. **The ranks are thus facing each other** and the inspecting officer passes between them.

INSPECTION OF ARMS.

If it should ever be the desire of a commanding or inspecting officer to, for any reason, inspect the rifles or arms of each man in the company, it is effected in the following manner. In case a company is part of a landing force ashore, where it is imperative that the rifles should be kept in perfect condition, each man caring for his own, **inspection of arms by the commanding officer of the company should be conducted each morning.**

The inspection is **always** conducted with the company at **open ranks**, the company being first brought to this position by the c. c.

Command (c. c.) — Inspection, Arms!

As the inspecting officer approaches the right of the company, the **inspection always being conducted from right to left (front rank first)**, the right guide or the right file executes **port arms** and **open chamber.**

The officer takes the piece, **grasping it with his right hand just above the rear sight** (the man meanwhile dropping his hands by his sides), **inspects** it, and, with the hand and piece in the same position as when receiving it, hands it back to the man, who **takes it with the left hand at the balance,** resumes the position of **port arms, closes chamber,** and comes to the **order.**

As the piece is returned, the next man to the left executes port arms and open chamber and so on through the front and rear ranks in succession.

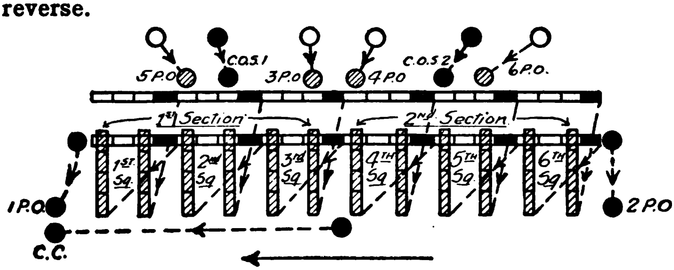
Sometimes an inspection is made without the officer taking the piece in his hand. In this case each man closes chamber and comes to the order as soon as the officer has passed the next man to his left.

Ranks are closed when the inspection is completed.

DRILLING THE COMPANY

SQUADS RIGHT (OR LEFT), MARCH!

This is a **move on a fixed pivot and serves to swing a company into a column of squads from a company front and the reverse.**



Squads Right — Column of Squads

Forms column from line; note positions of officers and p. os. in column; right and left guides (1 and 2 p. os.) on side of guide; c. c. on side of guide, marches abreast leading guide.

Each squad of the company executes the move on the c. c.'s command of execution, **march,** and in identically the same manner as was described for the single squad. **Each squad steps off together in the new direction on the fifth count after the command, march.**

The guides take position **on the flank** of the company **on which the c. c. has placed himself.** A simple rule governing the position of the guides is that in going squads right from a front, the right guide conducts himself as if he were number four of the rear rank of a preceding squad. In squads left from a front, the left guide conducts himself as if he were number one of the rear rank of a preceding squad. This principle is carried out throughout all evolutions. The rear guide always takes his position on the same flank as the leading guide.

The **line of file-closers** is two paces from the flank of the company, each file-closer being dressed or in line with the rear rank of his own squad. The file-closers are on the side of the column opposite to that of the c. c.

The **dress** or guide in marching column, after executing squads right, is toward the side of the c. c. and away from the line of file-closers.

TO EXECUTE SQUADS RIGHT AND HALT THE COMPANY WITHOUT ADVANCING.

This is done as was described for the single squad.

Command (c. c.) — **Squads right, March! Company.**

The command **company** immediately following the **march** of squads right signifies the company is to be halted. On completing the **squads right,** then, each man **marks time,** until **halt** is given by the c. c.

COLUMN RIGHT (OR LEFT), MARCH!

This **move is executed on a moving pivot and by a company in column of squads.** It serves to turn the column or the line of march to the right or left through an angle of 90 degrees. It is called **changing direction in column.**

At the c. c.'s command of execution, **march,** the first rank

of the leading squad, **pivoting on number one or four, whichever is on the turning flank, executes the turn as described for the single squad, under the heading, " squad, right turn."** All other squads and ranks continue forward, each turning in succession on the same ground as that on which the first rank turned and each executing the turn in the same manner.

The c. c., guides, and file-closers all stay on their original sides of the company, not changing during the turn.

The **guides are not the pivots for the turn, but the end files of the front rank.** In making the turn the guides take their positions and accommodate themselves to the position of the pivot man.

In making the turn it is the **tendency** of the ranks as they come up to the pivot to **take the turn by rounding it in a slovenly fashion. Each rank pivot man must march squarely up to the turning point and take the turn sharply through 90 degrees,** marching straight off in the new direction.

FILE-CLOSERS ON THE RIGHT (OR LEFT) FLANK, MARCH!

Often, in exercising a company, it is desirable or necessary to bring them into company front, so that the new front will be toward the line of file-closers. This, the evolution being completed, would leave the file-closers in front of the company.

To avoid such a situation, the above command by the c. c. would cause the file-closers to change their position to the opposite flank on the c. c.'s command of execution, **march.** Each file-closer goes through ranks to the rear of his own squad, being careful not to break up the formation.

C. c. and guides also change to the opposite flank.

RIGHT (OR LEFT) BY SQUADS, MARCH!

This is a combination of the two movements just described — **Squads right** and **column right** (or left). It **serves to bring a company from line or company front into a column of squads marching in the same direction** or toward the same front.

At the c. c.'s **march**, the command of execution, the **right squad marches straight to the front for four full paces, then takes eight half-steps, then goes forward again at a full step.** Every other squad in the company executes **squad right** at the command of execution; then **each squad in succession executes left turn falling in column of squads in the rear of the leading or right squad.**

The company is now marching in column of squads toward the same front as before, in the same position as if two commands, **squads right** and **column left**, had been given.

The **guides** take position in the same manner as if they had performed both evolutions referred to above, keeping on side of c. c.

The object in the first squad taking first, four full steps, then eight half-steps is this: first, the four full steps carries the squad clear of the second squad which is executing squad right; the eight half-steps permit the succeeding squads to carry out their evolutions and catch up to the leading squad.

This move can be executed from a company front, marching or at a halt.

COMPANY RIGHT (OR LEFT), MARCH!

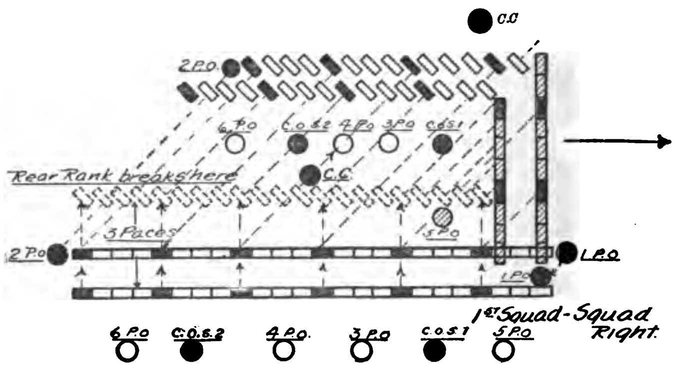
This move **turns the company on a fixed pivot.** It serves to bring the front of the company on a new front, facing 90 degrees to the right or left of the previous front. **It is executed only from the march. Never while a company is halted.**

At the c. c.'s command of execution, **march**, the right flank man of the front rank (**not the guide, but number one of the first squad) faces to the right, in marching, and marks time.** Every other front-rank man executes a right oblique, marching at the full step, until, as each man comes on the new line abreast of his right file, he faces half-right and **takes up the mark time**, glancing toward the pivot for his dress. **In the rear rank**, the first three men, numbers **1, 2, and 3 of the first squad, conduct themselves as in squad right.** All other rear-rank men advance **three paces to the front**, bringing the entire

rank as far forward as was number three of the first squad. At the end of the third pace forward, each rear-rank man executes right oblique as was done in the front rank, placing himself abreast of his right file, facing in the new direction and marking time; also covering his file-leader. The right guide of the company steps back into his proper position and marks time.

Command (c. c.) — **Company, Halt**!

The preparatory command, **company**, should be given when all except the last squad has completed the turn and is



COMPANY RIGHT

Turn on fixed pivot; mark time on new line; front rank breaks shoulders at "march"; rear rank advances 3 paces, then breaks

marking time. When the last man is one pace in rear of the new line, the execution command, **halt**, is given, when all men halt, remaining at attention.

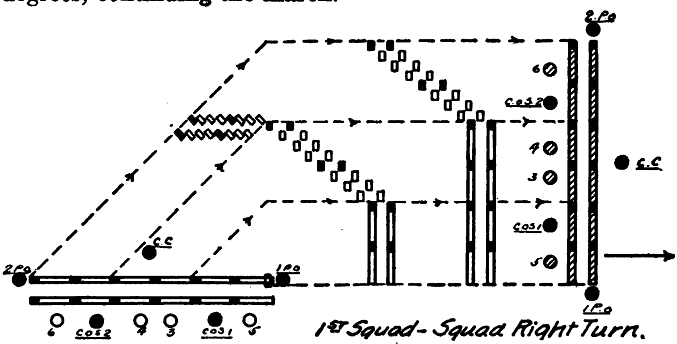
The c. c. can wait some time before giving the halt, if desired, keeping the men marking time until he considers their alignment satisfactory.

It is possible to march the company forward after the above movement has been completed and the company is marking time. This end can be attained in an easier way, however, and it is good practice to **halt** the company following an evolution of this kind.

In making the right obliques, it must be impressed on the men of each rank that they must go right oblique or break shoulders together.

COMPANY, RIGHT (OR LEFT) TURN, MARCH!

This **move is very similar to the company right move just described except that it is executed on the moving pivot.** It may be executed from either the halt or while marching, **but is usually executed from the march.** It serves to turn the front of the company to the right or left through 90 degrees, **continuing the march.**



COMPANY RIGHT TURN

Turning on moving pivot, advance at half step until "forward"; each rank breaks shoulders and turns in succession

At the c. c.'s command of execution, **march**, the right guide of the company faces right in marching and takes up the half-step in the new direction. Every other front-rank man goes right oblique at the full step until he uncovers the man to his right, when he executes another right oblique; he now marches forward, still at the full step, until he is abreast his right file, when he takes up the half-step, guiding toward the side of the pivot. The **rear rank** advances **forward two paces** after the command, **march**, then the whole rear rank executes right oblique on the same ground as that on which the front rank turned. The rear rank completes the turn as was explained for the front rank.

The whole company is now marching in the new direction at a half-step.

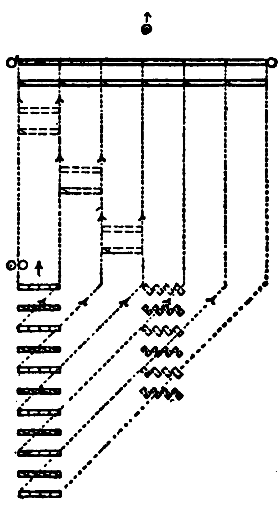
Command (c. c.) — Forward, march!

At the execution command, **march**, each man, front and rear rank, steps off with a full step. This command is given as a rule just as the last man arrives on the new line.

In the case of each of the foregoing evolutions, **company right**, and **right turn**, the guide, no matter what it was before, is on the pivot while the turn is being made, reverting to the original guide as soon as the turn is completed.

RIGHT (OR LEFT) FRONT INTO LINE, MARCH!

This move is executed when the company is in a column of squads. While it may be carried out either while the column is marching or at a halt, **it is common practice to execute the maneuver while on the march**, and there is little or no occasion to use it when the company is halted in column of squads.



COMPANY RIGHT FRONT INTO LINE

Each squad except first goes right oblique; each squad goes forward and halts at command of its own p. o.; c. c. gives "front"

Command (c. c.) — Right (or left) front into line, March!

At the command of execution, **march**, the leading squad of the column continues marching to the front, or, if halted, takes up the full step to the front; the guide comes back and takes his position abreast of number one man, front rank; the guide or dress of the squad is to the left. Each following squad to the rear of the first, at the command of execution, goes **right oblique** and marches at a full step, until each in succession uncovers the squad ahead, when each squad in turn and at the command of the squad

petty officer, **Squad Forward, march**! resumes the march to the front. All squads are now marching forward at the full step "in echelon"; that is, they slide off from each other at an angle of approximately 45 degrees.

Command (c. c.) — **Halt**!

Given when the leading squad has advanced the desired distance. At the command the leading squad halts and **executes left dress without further command.** Every other squad continues the march forward until it is one pace in the rear of the new line established by the leading squad, when each following squad in succession is halted at the command, **Squad, Halt**! of the squad p. o. The men of each squad execute left dress without command as they halt on the new line. **The company is now formed to the front and is at left dress.** The c. c. corrects the alignment, and when satisfactory, commands, **Front**!

The move as above explained brings the company to a halt in company front formation.

If, before the move is executed, the first squad is leading the column as is usual, the "**Right Front into Line**" **will bring the company into front "inverted." "Left Front into Line" will bring the squads into company front in their proper order.** If the last squad is leading the column, the reverse is true.

If the command is "Right Front into Line", each following squad **executes the oblique to the right** and falls in on the new line to the right of the leading squad, dressing toward the leading squad. If the command is "Left Front into Line", each following squad **obliques to the left** and forms on the new line to the left of the leading squad, and still dressing toward it.

RIGHT (OR LEFT) FRONT INTO LINE, DOUBLE TIME, MARCH!

This move is practically the same as the one just described, except that all squads in the rear of the leading one carry it out at the double time.

The object of the maneuver is to form company front from column of squads while on the march, and to continue the march in the same direction.

"Right Front into Line" halted the company at the completion of the move. Executed at double time, the same results are obtained and the march is continued; it not being necessary or possible to halt the company as a part of the move.

Command (c. c.) — **Right** (or **left**) **Front into Line, double time, March**!

At the command of execution, **march**, the leading squad continues the march forward at a full step. Every following squad executes **right oblique** and steps off at **double time.** They continue at the double time, each resuming the forward, at double time, at command of the squad p. o. when they uncover their preceding squad. As each squad in succession arrives on the line of march of the first squad, it resumes the quick time.

The c. c. having commanded, **guide left,** immediately after his command of execution, each squad, as it arrives on the line, marches guide left. **The march of the whole company is continued to the front, guide left.**

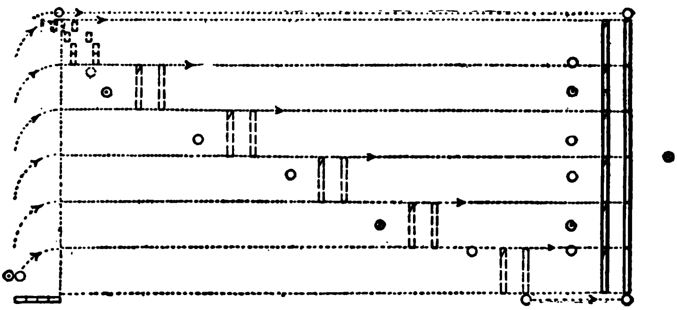
ON RIGHT INTO LINE, MARCH!

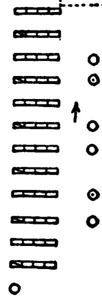
This move is also executed when the company is in column of squads, and, like "Right (or left) Front into Line", **it is common practice for it to be executed while the company is marching forward.** It is possible, however, to execute it from the "halt." The move is essentially the same as "Right (or left) Front into Line," already described, and is similarly executed. **The "Front into Line" move halts the company in "line" or "front" facing in the same direction as that in which the company marched in column of squads, while, "On Right (or left) into Line" also halts the company in "front" or "line", but facing to the "right" or "left" of the direction of march of the column of squads before the execution of the move.**

Command (c. c.) — **On Right** (or **left**) **into Line, March**!

At the command of execution, **march**, the leading squad of the column, whether marching or at a halt, executes **squad, right turn** on a moving pivot; each rank of the squad

stepping off **with** the **full step** in succession and without command, when all men in the rank have completed the turn and are abreast each other, marching at a half-step in the new direction. The leading guide of the company posts himself on the right of the leading squad. The guide or dress of the squad is to the **right**. Each following squad, to the rear of the first, at the command of execution continues





Company on Right into Line

Each squad executes *right turn* in succession; each squad halts on command of its own p. o.; c. c. gives "front"

the march to the front, or, if halted, takes up the full step to the front, advancing until opposite its new place in line, or, until it uncovers the preceding squad, when each squad in succession executes at the command of the squad p. o., **squad, right turn** as was explained for the leading squad. All squads are now marching forward at the full step " in echelon ", but in a direction to the right of the previous direction of march.

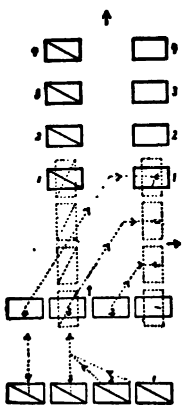
Command (c. c.) — Company, Halt!

Given when the leading squad has advanced the desired distance. At the command the **leading squad halts and executes right dress without further command.** Every other squad continues the march forward until it is one pace in the rear of the new line established by the leading squad, when each following squad, in succession, is halted at the command,

squad halt, of the squad p. o. The men of each squad execute right dress without command as they come to a halt on the new line. **The company is now formed in line to the right of the previous direction of march and is at right dress.** The c. c. corrects the alignment and when satisfactory commands **Front!**

If, before the move is executed, the first squad is leading the column as is usual, the **" On Right into Line " will bring the company into front with the squads in their proper order. " On Left into Line " will " invert " the order of the squads on the new company front.**

If the command is " On Right into Line ", the new company line is formed to the **right** of the previous direction of march, each squad executing **right turn.** If the command is " On Left into Line ", the new line is formed to the left, each squad executing **left turn.**



SQUAD RIGHT, MARCH! BY THE LEFT FLANK, MARCH!

Two distinct moves

(Showing execution by single squad)

SQUADS RIGHT (OR LEFT), MARCH! BY THE LEFT (OR RIGHT) FLANK, MARCH!

This move is always executed from a column of squads on the march and has as its object the reduction of the front of the column from four abreast to two abreast. This is done to enable the column to pass through a narrow gateway or defile or over a gangway and for no other purpose. The original formation in column of squads should be resumed as soon as the gateway, etc., has been passed and in such a manner as not to invert the squads or company.

Command (c. c.) — **Squads right (or left), March! By the left (or right) flank.**

At the command of execution, **march,** each squad executes **squad right** as in forming company front from column of squads.

The c. c., immediately following his command, **march,** commands, **By the Left Flank.** This signifies to the company that it is to execute, **By the Left Flank,** on the completion of the squads right movement, and that, after completing the execution of " squads right " in four counts **it is not to step off to the front with a full step on the fifth count, but is to " mark time " in company front, until the c. c. gives the command of execution " march ", for the carrying out of the " By the Left Flank " move.**

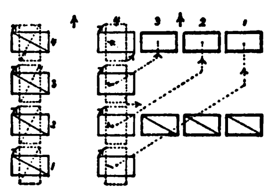
Command (c. c.) — **March!**

Each man in the company executes **By the Left Flank,** doing a left face, while marching, and steps off with a full step.

The company is now marching in double rank in the same direction as that in which the original column of squads marched.

Remember that in this move, two commands of execution are necessary to carry it out, as differentiated from the move to be explained next, where only one command of execution can be given.

The c. c. and file-closers maintain their positions on the same flanks, unless the c. c. should desire the positions changed, which he would bring about by the command, **File-closers on the left (or right) flank, March!** before any part of the evolution described above had been executed.



BY THE RIGHT FLANK, SQUAD LEFT, MARCH!

Executed together as one movement on the single command of execution

(Showing execution by single squad)

BY THE RIGHT (OR LEFT) FLANK, SQUADS LEFT (OR RIGHT), MARCH!

This move serves to bring the company back into a column of squads after it has passed through and is on the other side of the gateway, narrow defile, etc.

Command (c. c.) — **By the right (or left) flank, squads left (or right), march!**

It will be noticed that the full preparatory command for the whole move is given together in the same sentence. At the command of execution, **march,** each man in the company first executes, "**By the Right Flank**", and then, **without any pause,** the company swings into a column of squads, **each squad executing "squad left", simultaneously,** and **stepping off to the front or in the original direction on the fifth count.**

The company is now marching forward in column of squads in the same direction and in the same order as before the narrow gateway or passageway was encountered.

It will be noted that in this move only one command of execution, "march", is given, while in the move explained just previously, two such commands are necessary.

RIGHT (OR LEFT) OBLIQUE, MARCH!

This move for the company is executed exactly the same as has been described for the squad. Whether the company is marching in front or in column of squads, **each man, at the command of execution, does a half right face while marching,** and continues the march in this new direction, maintaining his position in the company both in rank and file; that is, he must maintain his position in his particular rank, keeping in line with the men to his right and left, and also he must keep in the rear or covering the man ahead of him. C. c., guides, and file-closers execute a half right face, and maintain relative positions the same as any other man in the company.

Command (c. c.) — Forward, march!

At the **march,** each man executes a **half left face** in marching and resumes the full step forward in proper formation.

The aim of this move is to carry the whole company, moving partly by the flank, a short distance to the right or left of its line of march so that its flank will avoid any obstruction in the street, etc. When the obstruction is avoided, the company can resume the "forward" quickly and without having altered the formation in the slightest degree.

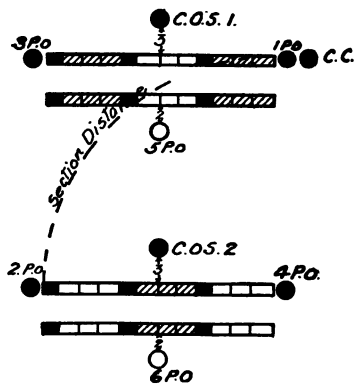
THE SECTION IN INFANTRY

Every company of infantry, no matter how many squads it contains, is divided into **two sections**, numbered the first and the second from right to left of the company facing in the same direction as the company front. Each section has a "chief of section", whose position is in the line of file-closers when the sections are in company line or in column. The sections are, when possible, made up of three squads each.

POSITIONS OF OFFICERS AND PETTY OFFICERS IN COLUMN OF SECTIONS.

The usual formation of a company, utilizing its sections, is **with the sections in column**; that is, the sections follow or cover each other; the first or right section usually leading and the second or left section following.

The distance between sections in column depends, of course, on the number of squads in the company and in each section. The rule is, **that the distance between sections should always be such that if any evolution brings the sections into company front, their flanks will just meet without interval, forming a properly aligned company.**



Column of Sections

The c. c. marches alongside or abreast the right guide of the leading section when the guide is right, and abreast the left guide if guide is left.

Each c. o. s. marches three paces in front of the center of his section.

The 1 p. o. is the right guide of the right section.

The 2 p. o. is the left guide of the left section.

The 3 p. o. is the left guide of the right section.

The **4 p. o.** is the right guide of the left section.

The **5 and 6 p. os.** retain their respective positions in the line of file-closers, in the rear of the proper squads in their respective sections.

RIGHT (OR LEFT) BY SECTIONS.

This move is the simplest one and the one most used in practice to bring a company into column of sections from a company front, either halted or marching.

Particularly, it forms the column of sections to the front and continues the march in such formation in the same direction as that in which the company was marching.

Commands (c. c.) — **Right by Sections.**

c. o. s. 1 — First Section, Forward.

c. o. s. 2 — Second Section, Mark time.

c. c. — March! Guide right (or left).

At the c. c.'s preparatory command, " Right by Sections ", the cs. o. s. each pass at double time around the outboard flanks of their sections, preparatory to taking their posts in the front of the center of same. At the same time the c. o. s. 1 gives the preparatory command " Forward " for his section and the c. o. s. 2 the preparatory command " mark time " for the second section.

When the c. c. has heard the preparatory commands of both section leaders, he gives his command of execution, **march,** immediately followed by the proper guide, as **guide right (or left).**

At the command of execution, **the first or right section continues the march forward,** if marching, or takes up the full step to the front, if halted. The **second or left section marks time,** until the right flank of this section is disengaged by the leading section, when at the command of c. o. s. 2, **right oblique, march!** the section takes up the oblique march. The command of the c. o. s. 2 is so timed that the command of execution for the oblique will be given the instant the flank of his section is disengaged. The second or left section continues the oblique until the command:

C. o. s. 2 — Forward, march! Guide right.

The command of execution is given the instant the left section covers over in column the right section, or when the right guide arrives in the trace of the right guide of the leading section.

As soon as the inboard flanks of the sections have cleared each other, the 3 and 4 p. os. jump up from the line of file-closers and post themselves as the left guide of the right section and the right guide of the left section respectively.

The company is now marching forward in the same direction, but in column of sections.

SECTIONS RIGHT (OR LEFT).

This move has as its object the formation of a column of sections from a company front or the reverse (company front from column of sections.)

There is this particular difference in forming a column of sections by this command from the manner in which it was done by the command "Right by Sections" just described. **"Sections right" forms the column facing in a direction 90 degrees to the right of the original front, and the move usually brings the column to a halt.**

The execution is on the fixed pivot for each section.

Command (c. c). — **Sections right, March!**

When the command is given, the company is marching forward either in column of sections or in company front. At the command of execution, **march,** the **right flank man in the front rank of each section pivots sharply to the right and "marks time."** Every other man in the front rank of each section goes right oblique and advances on to the new line, marking time, and lining up abreast his right file when he arrives on the new line. In the rear rank the first squad executes squad right and every other man advances three paces straight to the front, then goes right oblique, **carrying out the remainder of the move as has been explained under "company right."**

If forming company front, the guides on the inside section flanks drop back into the line of file-closers, permitting the company to close in. If forming column of sections, the

guides jump up and take their posts as soon as the sections have cleared each other.

The company is now " marking time " either in company front or in column of sections.

C. c. — **Company, Halt!**

This command is given if it is desired to halt the company or the column of sections after the turn has been completed. **It is usual to come to a halt after this move has been executed.**

In case it is desired to take up the march in the new direction without first coming to a halt, it can be done by the command:

C. c. — **Company, Forward, March!**

At the command of execution all men step off with the full step from the " mark time."

In forming column of sections from company front, the chiefs of sections double time to their positions in front of their particular sections as soon as possible following the first preparatory command of the c. c. In forming company front from column of sections the cs. o. s. return to their positions in the line of file-closers.

While, as has been stated, it is proper to use the foregoing maneuver in any case where it is desired to form a company front from a column of sections or a column of sections from company front, **in practice it is most often used to form a company front from a column of sections. Marching in column of sections, the command " Sections right " swings the unit into company front at the desired point, when the company can be halted and aligned or dressed.**

SECTIONS RIGHT (OR LEFT) TURN.

This move has the same object as " **Sections Right** " just described. It serves to form a column of sections from a company front or the reverse (company front from column of sections). It differs from " Sections Right " in one essential point — **it is executed on a moving pivot.**

C. c. — **Sections Right Turn, March!**

At the command of execution each section executes

simultaneously a **section right turn** in identically the same manner as was described for **company right turn.** When the turn has been completed and both sections, if in column (or the company, if in company front) are marching forward in the new direction at the half-step, the full step is taken up at the command:

C. c. — **Forward, March!**

The inside guides of both sections and also the **cs. o. s.** take places in column or in line of file-closers as described for "**sections right.**"

This move is used in practice as a rule in swinging into column of sections from a company front. For this purpose it has the advantage over **Sections Right** in that each section advances as it makes the turn, or the execution is on the moving pivot.

SECTIONS, RIGHT (OR LEFT) BY SQUADS.

Marching in column of sections, it is often desirable to resume "column of squad" formation quickly. The most simple way of effecting it is by the above maneuver.

C. c. — **Sections, Right (or Left) by Squads, March!**

At the command of execution, **march,** the right squad of each section advances to the front, taking first, four full steps, then eight half-steps, and then continuing at the full step. The following squads in each section each go squads right and then column left in succession covering in column the first or right squad. **Each section executes simultaneously in exactly the same manner as has been explained for "Company, Right by Squads."**

The above is executed in exactly the same manner either from a halt or from the march.

Cs. o. s. and inside guides resume position in line of file-closers.

SECTIONS, LEFT (OR RIGHT) FRONT INTO LINE.

When the company is marching forward in column of squads, a column of sections can be formed to the front or facing in

the same direction. **The execution of this move necessarily brings the column of sections to a halt when it is formed.**

C. c. — Sections, Left (or **Right**) **Front into Line, March**!

On the command of execution, **march**, each section simultaneously executes " Left Front into Line " as was described for the company, the leading squad of each section continuing the march forward and all following squads in each section executing first, **left oblique** and then **forward** when uncovering the preceding squad.

C. c. — Company, Halt !

At the **halt** the **right squad of each section** halts ; other squads continue the march, halting when they come on the line and executing **right dress. The unit is now in column of sections at a halt.** The **cs. o. s.** correct the alignment of the sections and each gives "**front**" for his own section.

SECTIONS, LEFT (OR RIGHT) FRONT INTO LINE, DOUBLE TIME.

Under the same conditions as in the previous case, it is desired to form a column of sections to the front, while marching in a column of squads. **This movement executed at double time, forms the column of sections and continues the march while the evolution is being carried out.**

C. c. — Sections, Left (or **Right**) **Front into Line, Double Time, March** !

At the command of execution, the leading squad of each section continues to march forward at quick time. Every other squad of each section executes left oblique at the **double time**, resuming the forward direction when uncovering the preceding squad. The double time is continued until each squad in succession arrives on the line of march of the leading squad, when it resumes the quick time, aligning itself on the leading or right squad and marching **guide right**. The company is now marching to the front in column of sections without any " halt " having been necessary to alter the formation from column of squads.

This is the usual manner of forming a column of sections from a column of squads on the march.

COMPANY, LEFT (OR RIGHT) FRONT INTO LINE, DOUBLE TIME!

Marching in a column of sections, this move brings the unit into company front while continuing the march.

C. c. — **Left (or Right) Front into Line, Double Time, March! Guide right!**

At the command of execution, **march,** the leading section of the company continues the march to the front at the quick time, guiding right.

C. o. s. 1 — **Guide right,** and cautions his section to continue forward.

C. o. s. 2 — **Left oblique, double time.**

The rear section goes left oblique, double time, at the c. c.'s command of execution referred to above. When the rear section has arrived abreast the right of the leading section on the line of march, it resumes the quick time at the command, **Quick time, March!** of the c. o. s. 2 and marches to the front, **guide right.**

When the sections have united in company front, the inside guides and cs. o. s. resume posts in line of file-closers.

The maneuver, while usually used in practice at the double time in the manner and for the purpose described, may be executed at the quick time, either marching or at a halt, and in the same manner as described for the foregoing, but subject to such slight changes as hold for other "Front into Line" moves carried out at the "quick time."

When the word "Company" is prefixed before the command, it conveys that the whole company is to be formed into line to the front; *i.e.*, marching in column of squads, the squads form in company line to the front; marching in column of sections, the sections form in company line to the front. When the company is the largest unit being drilled, it is assumed that the word "company" is prefixed before every command given, and it is not necessarily repeated before every command, the move being executed for the company if no other unit is specified.

When the word "Section" is prefixed, it conveys that each section is to be formed in section line to the front. Taking a

column of squads for example, "Sections Left Front into Line" would cause each section to form and the company would be in column of sections. "Company Left Front into Line" or just "Left Front into Line" would form the squads into company front.

The above rules hold good for any maneuver involving sections.

ON RIGHT (OR LEFT) INTO LINE.

Marching in column of sections, this move will cause company front to be formed in a direction to the right (or left) of the previous direction of march, and will necessarily bring the company to a "halt" in company front.

C. c. — **On Right** (**or Left**) **into Line.**

C. o. s. (**leading**) — **Right turn.**

C. o. s. (**rear**) — **Forward.**

C. c. — **March!**

The above preparatory commands are given by the cs. o. s. following the preparatory command of the c. c. At the c. c.'s command of execution, **march,** the **leading section executes right turn on a moving pivot**; the rear section continues the march forward until opposite its new place in line, to the left of the leading section, when at the command of c. o. s. 2, "**right turn,**" the rear section executes right turn on a moving pivot as was done by the leading section. The sections are now marching forward "in echelon."

C. c. — Company, Halt!

The leading section **halts** and executes right dress at the command of c. o. s. 1, who then takes his post. The rear section advances until it is one pace in the rear of the line established by the leading section, when it is halted at the command of c. o. s. 2, who then brings his section to right dress and takes his post in the line of file-closers. Interior guides fall into the line of file-closers.

C. c. verifies the alignment of the company front and commands "**Front.**"

COLUMN RIGHT (OR LEFT).

Marching in column of sections, it is desired to change the direction of march through 90 degrees to the right or left and maintain the same formation (column of sections).

C. c. — **Column right (or left).**

C. o. s. 1 — **Right turn.**

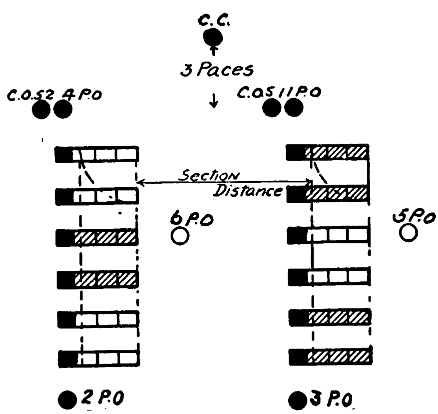
C. o. s. 2 — **Forward.**

C. c. — **March!**

When the c. c. has heard the preparatory commands of each of his cs. o. s. following his own preparatory command, he gives the command of execution, **march.** At this, the **first or leading section executes a right turn** on a moving pivot. **The second or rear section marches squarely up to the turning point and executes right turn at the command of** c. o. s. 2. As each section completes its turn and advances at the half-step its chief commands, **Forward, March!** at which the full step to the front is resumed by that section.

LINE OF SECTIONS

In the formation called "Line of Sections", each section is in column of squads and the columns are marching, or lined up at a halt abreast each other or in parallel lines. The distance between columns is such that if any maneuver should bring the sections into company formation, either in front or in column of squads, there will be no interval between sections.



LINE OF SECTIONS

The c. c. takes post 3 paces in front of the center of the company, on a line,

prolonged, which passes midway between the inboard flanks of the sections.

Each **c. o. s.** marches abreast his leading guide.

Guides take position in their respective sections as front and rear guides in the same manner as the guides in a company in column of squads.

5 and 6 p. os. retain their positions in the line of file-closers.

The **Line of Sections** formation is advantageous in many ways and is frequently used. It can be used in combination with many of the evolutions already described. A few possible and simple moves are covered briefly.

TO FORM LINE OF SECTIONS FROM COLUMN OF SECTIONS AND THE REVERSE.

Marching in column of sections, it is desired to change the formation to Line of Sections while marching and to change direction to the right of the previous direction of march.

C. c. — **Squads Right, March**!

Each section executes simultaneously and is marching to the right in Line of Sections.

C. c. — **Squads Left, March**!

The execution of this, simultaneously by each section, resumes the section formation, marching to the front.

TO FORM LINE OF SECTIONS FROM COMPANY FRONT AT HALT OR MARCHING.

C. c. — **Right by Squads, March**!

Simultaneously, each section executes, forming line of sections marching in the same or original direction.

TO FORM COLUMN OF SQUADS (COMPANY) FROM LINE OF SECTIONS.

Marching in line of sections, it is desired to resume column of squad formation in company, changing the direction of march to the right or left.

C. c. — **Sections, Column Right** (or **Left**) **March**!

Each section simultaneously executes column right, swinging into one company column. Interior guides and cs. o. s. fall into the line of file-closers.

TO DISMISS THE COMPANY

The company is lined up at a halt, the drill, etc., being completed. The c. c. directs the 1 p. o. to **dismiss the company.** The c. c. returns the salute of the 1 p. o. and then c. c. and cs. o. s. fall out.

The 1 p. o. with rifle at the order salutes the c. c. with rifle salute, steps three paces to the front, faces left toward the company and commands — **Port, arms! Open, chambers! Close, chambers! Dismissed!**

The company is dismissed with the pieces at the port, it being not necessary to require their being returned to the position of order.

THE BATTALION

A **BATTALION OF INFANTRY consists usually of four companies,** and, as covered in the following, it will be assumed that it is composed of four companies. A **battalion may, however, be composed of any number of companies, not less than two nor exceeding six.** In forming or organizing a battalion for drill or parade purposes aim always to have four companies, if it is in any way possible to do so.

The companies in battalion front or line are arranged from right to left, according to the relative rank of the company commanders present at the formation, the senior being at the right of the line and the junior at the left. Right and left, as here used, refer to the actual right and left as the battalion line faces. The companies as now placed are numbered from right to left, number one on the right and increasing numerically to number four on the left. The companies retain these numbers throughout the particular drill, no matter how they may become transposed or inverted in the battalion.

The aim in drilling a battalion or any other unit, large or small, is to keep the organization from being inverted. In a battalion, the first company should always be either at the right of the line or at the head of the column. In any other arrangement the battalion is inverted; that is, the com-

panies are not in their proper positions. Conditions often arise where it is necessary to invert a battalion in order that certain evolutions may be carried out expeditiously. When this is the case, keep the inverted formation for as short a time as possible, taking the first opportunity of bringing the unit back into its proper marching order. When inverted, if the fourth company is on the right of the line or at the head of the column, it is still the fourth company, but is designated in commands as the **right company** or the **leading company,** as the case may be. Other companies are designated in similar fashion according to their location in the battalion, as **left company, left center company,** etc.

POSTS OF OFFICERS AND PETTY OFFICERS. IN BATTALION FRONT OR LINE.

Battalion commander — 20 paces in front of the center of the battalion line.

Adjutant — At the right of the line, six paces in the rear of the line of file-closers and covering directly in rear of the right file of the first company. The **duties of the adjutant** are, with respect to the battalion, somewhat similar to those of the first petty officer with respect to the company. He is responsible to the battalion commander for the formation of the battalion and for its alignment.

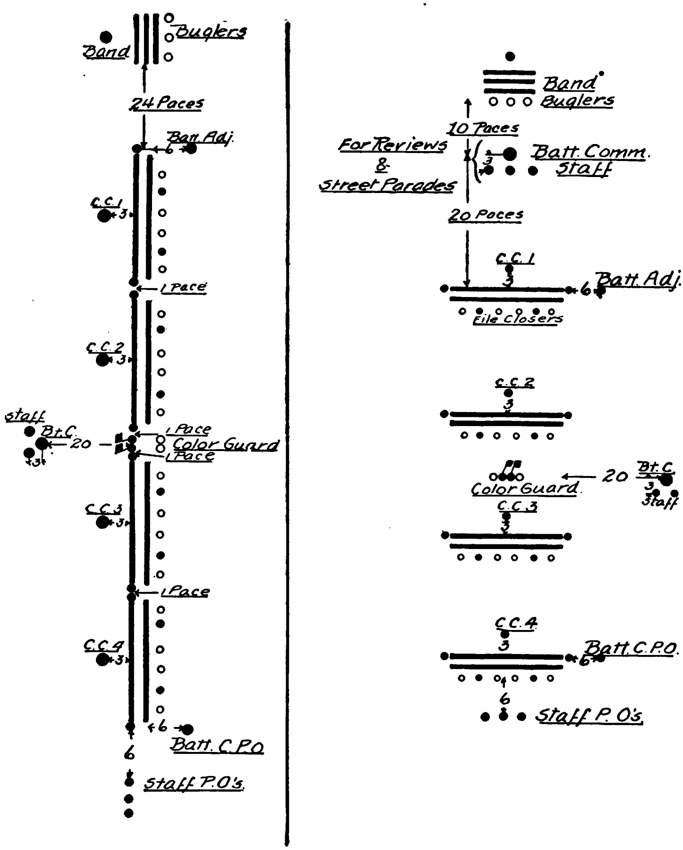
Chief Petty Officer — At the left of the line; otherwise the same as that of the adjutant. **His duties are to assist the adjutant** as directed, particularly in forming and aligning the battalion.

Staff Officers — In line, three paces in the rear of the bt. c. They are one pace apart and in the order of rank, senior on the right. If only one staff officer is present, he takes post three paces to the rear and one to the right of the bt. c. The adjutant, although a staff officer, has his own post on the right of the line, as stated. Staff officers are present, as a rule, only during parades, reviews, and similar functions. During such functions, the adjutant takes his post on the right of the staff.

Staff Petty Officers — In line, one pace apart, and in order

of rank, senior on the right. Take post six paces to the left of the left flank of the battalion and on a line with the front rank. Present, as a rule, only when staff officers are present, during reviews, etc.

Company commanders, chiefs of sections, and company petty officers retain positions in the company the same as if they were operating singly.



BATTALION

Battalion Line or Front — Column of Companies

POSTS OF OFFICERS AND PETTY OFFICERS. IN COLUMN OF COMPANIES, SECTIONS, OR SQUADS.

Battalion commander — Marching on the side of the guide, opposite the center of the column and twenty paces away from the marching flank.

Adjutant — Marching on the side of the guide, opposite the head of the column; that is, opposite the first petty officer or guide of the leading company and six paces to the right or left of the marching flank.

Chief Petty Officer — Marching on the side of the guide, in exactly the same position as that described for the adjutant except that he is opposite the rear of the column.

Staff Officers — In line behind the bt. c.

Staff Petty Officers — In line, six paces in the rear of the line of file-closers of the rear company or the rear subdivision of the column.

Company commanders, chiefs of sections, company petty officers retain positions as outlined in their particular companies. **C. cs. are on the same flank as the bt. c.**

FORMING THE BATTALION.

Adjutant's Call is sounded on the bugle when all companies have formed individually on the parade grounds.

The **adjutant,** as soon as the call sounds, **proceeds to the point where the base-company of the battalion is to form,** thus determining the position of the battalion line. The **chief petty officer** reports to the adjutant and is posted by him on the battalion line and facing the adjutant at a distance a little greater than that of the length of a company front. **The adjutant now draws his sword.** He and the c. p. o. are now marking the section of the line on which the base-company is to form; all other companies then forming on the base-company.

Also, at the adjutant's call on the bugle, all companies take up the march simultaneously at the command of their c. cs., and are conducted by such a route as to come on the battalion line from the rear and in proper succession, coming

up to their respective positions on a line of march parallel to the battalion front.

The center company is usually designated the base-company. In a battalion composed of an even number of companies, the center company is the left company of the right wing or right half of the battalion. **When there are four companies, the second company is the center and base-company.** In case there are an odd number of companies in the battalion the actual center company would be designated the base-company. **If no designation is made, the center company is assumed by its c. c. to be the base-company and is conducted as such.**

The base-company is conducted by its c. c. toward the point marked by the positions of the adjutant and c. p. o., approaching it from the rear and on a line parallel to that established by the adjutant and c. p. o. **The usual formation is to bring the company up in a column of squads, the line of march being at least twenty paces behind the new battalion line and parallel to it.** When almost opposite the place to be occupied by his company in the line, the c. c. commands, "**guides on the line, March!**" The right and left guides of the company **leave the formation at the command of** execution **and precede the company to the line at the double time, rifles at the position of "port."** Arriving on the line, they come to the "**order, arms**" and are posted by the adjutant and c. p. o., **facing to the left** or **point of rest** (the point on which the battalion is dressed, in this case the center of the battalion in line). Their position is such that their elbows should rest against the breasts of the right and left files of the company when it is dressed on the line. When, after ordering his guides on the line, and the company, still in column of squads, arrives opposite the point marked as its position in line, the c. c. commands "**squads left**" and the company marches down in company front toward the line marked now by its right and left guides. The c. c. brings his company to a halt one pace in the rear of the line of the guides and commands "**left, dress.**" The company executes as for the company and faces to the front at the

c. c.'s "**front**" when the alignment is completed. The c. c. **in commanding** "left dress" **and in correcting the company** alignment takes his post at the left of the front rank, abreast the left file and in the place vacated by the left guide. At "**front**" he takes his post in front and center of his company, facing front or in same direction as the company and with his sword at the order.

The other companies arrive on the line in the same manner, and in succession, sending their guides to the line preceding them by about twenty paces. As the guides arrive on the line they are posted by the adjutant and the c. p. o., the adjutant aligning the guides of the right wing companies by placing himself in the rear of the right guides of companies as they successively arrive. The c. p. o. similarly aligns the guides of the left wing companies by placing himself in the rear of the left guides of companies as they successively arrive.

The companies of each wing of the battalion arrive on the line in succession from the center, dressing on the line established by the guides and on the command of the respective c. cs.

The companies of the right wing dress to the left or toward the point of rest, which is the center of the battalion.

In dressing companies in line or in battalion front, **c. cs. are in prolongation of the front rank and on the side or flank toward which the dress is to be made**; *i.e.*, for right wing companies on the left; and for left wing companies on the right flank.

When the battalion is formed to the front and dressed, there should be one pace interval between the guides of adjacent companies.

When all companies are on the line, the adjutant is on the extreme right and the c. p. o. on the extreme left, they having fallen back in posting the guides. From the right of the line, the adjutant verifies the alignment of the battalion, correcting it if necessary by calling on the commanders of any companies not in proper position to alter the same as directed. When the alignment is satisfactory, **the adjutant**

moves from his position on the right of the battalion, taking the shortest route (diagonal line) to a point midway between the post of the battalion commander and the center of the battalion; he then faces the battalion.

The **battalion commander** has just previously taken post in front of the center of the battalion line, at a distance from the line equal to about half the length of its front.

The adjutant is still in command of the battalion, however, and causes the execution of the following:

Command (adj.) — **Guides, Posts!**

The command is given when all parts of the line have been correctly aligned, and officers are at their posts, **c. cs. in front of their companies, facing front, with swords at the order.** At the command of execution, **posts,** the guides jump back into position, resuming their post in the company line. The battalion c. p. o. and the staff p. os. also take positions in line at this command.

Command (adj.) — **Present, Arms!**

At the command of execution, officers and men come to present with sword and rifle and retain this position. This is their salute to the battalion commander.

The adjutant faces about, salutes the bt. c. with sword and reports: **Sir, the battalion is formed.** The bt. c. returns the salute with his right hand and directs the adjutant: **Take your post, sir.** He then draws his sword and assumes command of the battalion. The adjutant returns to his post in line, facing about, and moving to his post at the right of the line at the quick step and by the shortest route.

Command (bt. c.) — **Order, Arms!**

Given as soon as he has drawn his sword and assumed command.

The battalion has now been formed and is ready for drill, parade, etc.

TO OPEN BATTALION RANKS.

The object is to open the ranks for purposes of inspection of the battalion, so that there is three paces between front and rear ranks.

The battalion is in line, at a halt.

Command (bt. c.) — **Open ranks.**

The **adjutant** places himself facing to the left, three paces to the right and three paces to the rear of the front rank. **Chiefs of sections and right and left guides of all companies; also line of file-closers,** take posts as prescribed for the individual company, **the guides being aligned by the adjutant,** who then places himself facing to the left, in a line with the company commanders and three paces from the right flank of the battalion.

Command (bt. c.) — **March!**

Company commanders **carry swords** and dress to the right. Chiefs of sections take posts on line with c. cs., also dressing to the right; all officers turn head and eyes to front when their alignment is verified, which is now done by the adjutant. They keep their swords at the carry, or on shoulder.

The **front rank** of the battalion executes **right dress** at the command, **march.**

The **rear rank** of the battalion **marches backward, guide right,** halting on the line established by the guides, three paces in the rear of the front rank. The rear rank remains at right dress. The right guides of companies align the rear-rank men in their respective companies.

Staff petty officers, if present, dress right with the front rank.

The foregoing are all executed simultaneously at the bt. c.'s **march.**

The **adjutant corrects or verifies the alignment** of both ranks and file-closers, and then takes his post, facing front, in line with the company officers, and three paces to the right of the front rank. The adjutant taking his post is the signal to the bt. c. that the alignment is complete.

Command (bt. c.) — **Front!**

Guides resume their posts in the front ranks of their respective companies.

Men in front and rear ranks snap head and eyes to front.

Company officers bring swords to "order."

The c. p. o. takes post three paces to the left of and in line with the front rank.

Battalion is now at attention and ranks are open ready for inspection.

During a routine inspection each company commander should accompany the inspecting officer while his own company is under inspection.

TO CLOSE RANKS.

From the foregoing position of **open ranks** to close the ranks again, resuming regular battalion formation in line.

Command (bt. c.) — **Close ranks, March!**

At the command of execution, the rear rank closes in, marching forward to its regular position, 36 inches in rear of the front rank. The execution is done simultaneously by all companies at the bt. c.'s **march**, and is executed by each in identically the same manner as has been described for the individual company.

TO ALIGN THE COMPANIES IN BATTALION FRONT OR LINE.

Command (bt. c.) — **Rectify the Alignment.**

Immediately, at the command, the company commanders of the center companies dress their companies from the center; being careful to preserve one pace interval between the guides. The right center company does "left dress" and "front" at the command of its c. c. The left center company similarly dresses to the "right." Other right wing companies execute **left dress** in succession from the center at the command of their c. cs., while other left wing companies are similarly dressed to the right in succession.

The command is given by the bt. c. when the battalion is brought into front with a ragged line. It corresponds to "right (or left) dress" by the company.

When an especially good alignment is desired, the bt. c. can bring out or post the guides and have them dressed and the companies then dressed on the guides by the battalion adjutant.

The following commands would be given by the bt. c.

Guides center company on the line.

The designated guides step out and post themselves as in forming battalion line, facing toward the center.

(**Bt. c.**) — **Guides on the line!**

Guides of all other companies step out and post themselves, facing either right or left toward the center of the line.

(**Bt. c.**) — **Center, Dress!**

At the command, **dress**, each c. c. simultaneously dresses his company toward the center of the battalion line, or toward the flank toward which his guides are facing.

(**Bt. c.**) — **Guides, Posts!**

Guides return to positions in line and battalion is dressed, or alignment has been rectified.

USUAL BATTALION FORMATIONS

The **battalion is in line or front** when all companies are stretched out in a long line, abreast each other, and each in company front.

The **battalion is in column of squads** when each company is in column of squads, one following the other.

The **battalion is in column of companies** when the companies follow each other in succession, each in company form or line.

The **battalion is in line of companies** when the companies march abreast each other, each in column of squads.

The **battalion can similarly be in column of sections or line of sections**, the section being the unit instead of the company.

BATTALION, SQUADS RIGHT (OR LEFT), MARCH!

The object as a rule is to **change the formation from a battalion front to a column of squads, or vice versa.**

Command (bt. c.) — **Squads Right** (or **Left**), **March!**

Each company commander repeats the preparatory command, **squads right**, to insure every man in the company understanding the move to be executed.

The bt. c. waits several seconds between his preparatory command and the command of execution, to insure its being thoroughly understood and to give c. cs. an opportunity to repeat the preparatory command. At the bt. c.'s command of execution, **march**, each company simultaneously executes squads right as explained for the company, stepping off at the fifth count with a full step in the new direction and in the new formation.

The move can be executed either from a halt or from the march; and after executing squads right (or left) the battalion can be halted in line without advancing by commanding "**battalion,**" immediately after the execution command, **march,** of **squads right.** The battalion then marks time on the new line until the bt. c. commands "**halt.**" This is the same as is done in the case of the company.

In battalion formation it is not necessary to prefix the command each time with "**battalion.**" Merely, **Squads right, March,** will suffice, the " battalion " being understood.

After the battalion has been formed in battalion front on the field, it is customary and good practice in marching off to swing first into column of squads, and then later into such other formation as is desirable.

While the primary use of squads right (or left) is in forming a column of squads from line and vice versa, it is useful in many other formations; for example, **to form a line of companies from a column of companies and vice versa,** the command is **Squads Right (or Left), March**! It is executed simultaneously by companies.

BATTALION, COLUMN RIGHT (OR LEFT), MARCH!

The battalion can be marching forward in column of squads, sections, or companies. **The move effects a change of the direction of march of the column to the right or left through an angle of 90 degrees.**

In column of squads.

(**Bt. c.**) — **Column right.**

(**C. c. 1st co.**) — **Column right.**

(Bt. c.) — March!

At the command **march** of the bt. c., the first company pivots, executing column right as described for the company. **Each succeeding company continues the march forward** until arriving at the point on which the first company changed direction, when the c. c. gives both the preparatory command and the command of execution as if he were turning the individual company. The command of execution, **march**, should be given by each succeeding c. c., when the flank man of the leading squad arrives at the turning point.

In column of sections.

(Bt. c.) — Column right.

(C. o. s. 1st Sect.) — Right turn.

(Bt. c.) — March!

At the command, **march**, of the bt. c. the **first section executes right turn** as prescribed for the company and section. **Each succeeding section continues the march forward,** executing right turn in succession at the commands of their cs. o. s. and on the same ground as that on which the first section turned.

In column of companies.

(Bt. c.) — Column right.

(C. c. 1st Co.) — Right turn.

(Bt. c.) — March!

At the command, **march,** of the bt. c. the first company executes **right turn** as prescribed for the individual company. Each succeeding company continues the march forward, executing the right turn in succession at the command of their c. cs. when arriving on the ground on which the first company turned.

When executing the column right while in column of sections or companies, the leading section or company takes up the full step in the new direction, after making the turn, at the command "forward, march!" of its c. o. s. or c. c. Each succeeding section or company takes up the full step after making the turn, at the command, "**forward, march!**" of its own c. o. s. or c. c.

SIMULTANEOUS EVOLUTIONS IN THE BATTALION.

Simultaneous evolutions in the battalion are those in which all companies (or sections, if in section formation) execute the evolution together or simultaneously on command of the bt. c.

In a move of this nature, each c. c. repeats the preparatory command of the bt. c. for the benefit of his own company. At the bt. c.'s command of execution, all companies execute together or simultaneously.

Squads Right, March! is a move of this nature.

Companies, Right Turn, March!—Each company executes the right turn together on the bt. c.'s **march.** The command, **forward, march!** when the turn is completed is also given by the bt. c., it being necessary for him to do so in this case in order that the companies maintain their distance or alignment marching in the new direction.

Companies, Right, March!—Each company executes together. The object, as a rule, is to form a battalion line from a column of companies. The bt. c. commands, **battalion, halt!** when all companies have made the turn and are marking time, facing in the new direction.

Companies, Column Right, March!—Marching in column of squads, each company executes "**column right**" together on the bt. c.'s command of execution. The battalion is now in "**line of companies.**"

Companies, Right by Squads, March!—Marching in column of companies, each executes "**right by squads**" at the bt. c.'s **march,** the move being simultaneous by companies. The battalion is now in column of squads marching in the same direction.

Companies, Left Front into Line, Double Time, March!—Marching in column of squads, the simultaneous execution

of this command brings the battalion into a column of companies, continuing the march in the same direction.

The foregoing and a number of other evolutions may be executed simultaneously by the companies or sections of a battalion. Every move explained can be adapted to the section, by replacing the word "company" in the command by the word "section."

Battalion, preceding a command, means that the battalion executes the move as a unit. When drilling a single battalion, the term "battalion" is understood as preceding the remainder of the command if no other unit is designated.

Company, preceding a command, when there are several companies drilling in battalion, means that each company executes for itself as a unit and simultaneously with other units.

Section, preceding a command, means that each section in the battalion executes as a single section would, but at the command of the bt. c., and simultaneously with other sections.

SUCCESSIVE EVOLUTIONS IN THE BATTALION.

Successive evolutions in the battalion are those in which each company (or section, if in section formation) executes the evolution in turn or in succession, the first or leading company executing at the command of execution of the bt. c.

In a move of this nature, the c. c. of the first or leading company repeats the preparatory command of the bt. c., and the first company executes on the bt. c.'s command of execution. The c. c. of each succeeding company maintains his company in the old formation until on the ground on which the leading one changed its formation, when he gives both commands, preparatory and execution, as are necessary to cause his company to follow the leading one in column, the evolution of course being the same as the one executed by the leading company.

Column Right, March! in a column of squads, sections, or companies is a move of this nature.

Column of Squads, First Company, Right by Squads, March! — Marching down a thoroughfare in column of companies where the noise makes it difficult to carry out simultaneous moves, the above method is utilized to form a column of squads to avoid some obstruction such as an excavation in one side of the street.

The above preparatory command is given by the bt. c. The c. c. repeats the preparatory command, **right by squads,** for his own company. At the bt. c.'s **march,** the leading company executes. All other companies continue forward, then each in succession execute **right by squads** at the command of its c. c., in the same manner and on the same ground as the leading company executed.

Column of Companies, First Company, Left Front into Line, Double Time, March! — This move is the reverse of the one previously described. It forms a column of companies in succession from a column of squads.

Column of Sections, First Company, Right by Sections, March! — This is similar to the foregoing moves. Marching in column of companies, it alters the formation, forming column of sections, successively to the front.

Column of Squads, First Company, Squads Right, March! — Marching in column of companies, it is desired to change direction to the right (or left) and at the same time reduce the size of the front. The first company executes **squads right** at the command of the bt. c. Other following companies execute in succession as they arrive on the ground on which the leading company executed. An ideal use for this move is when, marching down a fairly broad thoroughfare in company front, it is desired to turn at right angles into a narrow side street.

Column of Companies, First Company, Squads Right, March! — This is the reverse of the foregoing move, forming a column of companies to the right, in succession, from a column of squads.

The foregoing and several other evolutions may be executed in succession by the companies or sections of a battalion. Every move explained can be adapted to the section by replacing the word "company" wherever it occurs in the command by the word "section."

In commanding and exercising a battalion it must be continually kept in mind that neither the companies, sections, nor squads should be inverted either in line or in column formation, and that when it is absolutely necessary to invert them, they must be kept in an inverted formation for as short a time as possible, returning to the proper order at the first opportunity.

Sometimes, to straighten out a badly inverted battalion, all your ingenuity must be brought into play. Always remember the last command you gave. If it was **squads right,** the reverse, **squads left,** will restore the original order. If your last command was **sections, left by squads,** the reverse, or **sections, right front into line, double time,** will straighten you out, continuing the march.

The battalion commander must be especially particular in his manner of giving commands. This applies equally to company commanders and chiefs of sections. The preparatory command should be long and drawn out, but clear and loud so that all will get it distinctly. The execution command must be short and sharp. It will cause the companies to execute it in a quick and snappy manner. **There must be a pause of several seconds at least between the preparatory and execution commands, to give an opportunity for all to decide what they are going to do and prepare to execute.**

TO FORM BATTALION LINE OR FRONT BY COMPANIES IN SUCCESSION

The following moves are called "**Successive Formations.**" They aim to form a battalion front, the companies of the battalion arriving on the line in succession.

In all successive formations into battalion line, **the guides of the company first to arrive on the line are posted as soon**

as the company is halted. At the command of the c. c. "**Guides on the Line**", given as soon as the first company is halted on the line in company front, both guides step out opposite the right and left files of the company, facing toward the point of rest. They are posted, and their alignment is verified by the battalion adjutant and c. p. o. As the other companies arrive on the battalion line in succession, their guides precede them by about twenty paces, being posted by the bt. adj. and c. p. o. the same as when the battalion was originally formed. **The guides of all companies face toward the point of rest. If the first company arrived first on the right of the new line, it would " dress right " and its guides would face to the right. Succeeding companies would " dress right " on the first company as they arrived on the line and their guides would all face right.**

The companies, as they arrive on the battalion line, are halted by their c. cs. one pace from the line of guides and are then immediately dressed up to the line of guides and toward the point of rest at the command of the c. cs. in identically the same manner as was described under the "**Formation of the Battalion.**"

When the last company has arrived on the line and its dress has been completed, the bt. adj. and c. p. o. take their posts at the right and left of the line, respectively. The bt. c. from his position in front of the center of the battalion commands "**Guides, Posts!**" at which the guides jump back into position, executing on the command "**Posts.**"

ON RIGHT (OR LEFT) INTO LINE — FROM COLUMN OF SQUADS.

Marching in column of squads, the object is to bring the battalion into line to the right (or left) of the direction of march, the companies arriving on the line in succession.

Commands (Bt. c.) — On Right into Line.
(C. c. 1st Co.) — Squads right.
(C. cs. — All following co.'s) — Forward.
(Bt. c.) — March!

At the **bt. c.'s march,** the **first company immediately**

executes squads right, marching off in the new direction. All following companies continue the march forward; or, if halted, take up the forward march.

The second company continues forward until it uncovers, to the right, the leading company, when the c. c. gives, **squads right, march,** and the company executes squads right and marches off in the new direction as was done by the first company.

Each succeeding company is conducted in the same manner by its c. c., executing squads right in succession as the preceding company is uncovered.

(**Bt.** c.) — **Battalion, Halt !**

The halt may be given at any time after the leading company has executed squads right and is marching in the new direction in company front. Usually it is given when the first company, in company front, has advanced several paces. At the bt. c.'s "**halt**", the first company comes to a halt. Each succeeding company, whatever its position may be when the bt. c.'s halt is given, continues its march and is halted by its c. c. as it arrives on the battalion line. Each company as it arrives on the line is dressed to the right by its c. c. **It is not necessary for the bt. c. to wait until all companies have executed squads right or until they are all in company front before giving his command, " battalion, halt ! "**

" On Right into Line " is not usually a good move to execute as it forms line with the squads in each company inverted.

" On Left into Line " forms the line with the squads in proper order in their companies, but the companies are inverted in the battalion.

Executed either to the right or left it is a move calculated to fit special cases. For instance, if in your column of squads, the squads or companies were inverted, the execution of either " On Right (or On Left) into Line " would serve to bring the battalion into line in the proper order.

ON RIGHT (OR LEFT) INTO LINE — FROM COLUMN OF COMPANIES.

Marching in column of companies, the object is to form battalion line as was done from column of squads.

Commands (**Bt. c.**) — **On Right into Line.**
(**C. c. 1 Co.**) — **Right turn.**
(**C. cs. — All following co.'s**) — **Forward.**
(**Bt. c.**) — **March!**

At the bt. c.'s **march**, the **first company immediately executes right turn.** The c. c. gives **forward, march** as the turn is completed and the company marches off at a full step, in the new direction in company front. All following companies continue the march to the front, or, if halted, take up the forward march.

The second company continues forward until it uncovers, to the right, the leading company, when the c. c. gives, **right turn, march** and the company executes right turn and marches off in the new direction, after taking up the full step at the command of the c. c. in the same manner as was done by the first company.

Each succeeding company, in the same manner, is turned by its c. c., executing right turn in succession as the preceding company is uncovered.

(**Bt. c.**) — **Battalion, Halt!**

The halt may be given at any time after the leading company has executed right turn and is marching in the new direction at the full step. It is not necessary to hold the "halt" until all companies have executed the right turn. At the bt. c.'s "**halt**" the first company comes to a halt. Each succeeding company continues forward until it arrives on the line established by the first company, when it is halted at the command of its own c. c. Each company as it arrives on the line in succession dresses right on the command of its c. c.

"**On Right into Line**" **from column of companies keeps the battalion in the proper order,** presuming of course that the first company was leading the column when the command was given. "**On Left into Line**" **forms battalion front with**

the companies inverted, the first company on the left and the fourth on the right of the line.

RIGHT (OR LEFT) FRONT INTO LINE — FROM COLUMN OF SQUADS.

Marching in column of squads, the object is to bring the battalion into line to the front or facing the same as the direction of the march, the companies arriving on the battalion line in succession.

Commands (**Bt. c.**) — **Right Front into Line.**
(**C. c. 1 Co.**) — **Column right.**
(**C. cs. — All following co.'s**) — **Column Half Right.**
(**Bt. c.**) — **March !**

At the battalion commander's **march,** the **leading company** executes "**column right**" and **each following company** executes "**column half right.**"

The bt. c. is now through with the move. It is completed by the c. c.'s.

C. c. 1 Co. — Squads left, march ! — Company.

As soon as the last squad of the leading company completes the column right, **the company executes squads left at the command of the c. c. and marks time, preparatory to halting.**

C. c. 1 Co. — Halt ! Left, Dress !

The company is halted, forming the base of the new battalion line and is dressed to the left.

The c. cs. of each of the following companies conduct their companies by the most convenient route, usually column half right, to the rear of the right flank of the preceding company which is already on the line. Another column half right is then executed at the command of the c. c. This alters the direction of march so that it is parallel to the battalion line and four paces to the rear of it. When the company is opposite its place in the battalion line, **squads left, march** ! is given by the c. c. **The company executes and advances in company front on to the new line, being halted one pace in the rear of it by the c. c. and then dressed to the left.**

"Right (or Left) Front into Line" moves are, similarly to the "On Right (or Left) into Line" moves, not as a rule good moves to execute, as they form the line with squads or companies, or both, inverted.

"**Right Front into Line**" forms battalion front with the companies inverted in the battalion, the first company being on the left of the line.

"**Left Front into Line**" forms battalion front with the companies in proper order, but with the squads in each company inverted. In "**left front into line**" the first company executes **column left** and the succeeding companies **column half left** at the bt. c.'s **march.**

RIGHT (OR LEFT) FRONT INTO LINE — FROM COLUMN OF COMPANIES.

Marching in column of companies, the object is to form a battalion line to the front as was done from a column of squads. It is possible for the command to be given when the column is at a halt.

Commands (Bt. c.) — Right Front into Line.
(C. c. 1 Co.) — Company.
(C. cs. — All following co.'s) — Squads right.
(Bt. c.) — March!

At the battalion commander's **march, the first or leading company halts,** having already been given the preparatory command, **company,** of the halt, by the c. c. Every following company executes **squads right** at the bt. c.'s **march.**

The bt. c. is now through with the move. It is completed by the c. c.'s.

The first company is immediately dressed to the left, by the c. c. after coming to the halt. **The c. cs. of each of the following companies, after executing "squads right", conduct their companies by the most convenient route to the rear of the right of the preceding company which is already on the line.** The **second company in column usually continues in column of squads** past the rear of the first company, until opposite its place in line, when it executes "squads

left " on the command of the c. c., advancing on to the line in company front. **The companies in the rear of the second usually advance toward their place in line at " column half right ", completing the move in exactly the same manner as has been described for the execution from a " column of squads."**

" Right Front into Line " forms battalion front with the companies inverted, the first company being on the left of the line.

" Left Front into Line " forms battalion front in the proper order.

FORM LINE, FIRST COMPANY, ON RIGHT (OR LEFT) INTO LINE, MARCH!

Marching in column of squads, it is desired to form a battalion line to the right of the direction of march **and so that in the battalion line neither squads nor companies are inverted.** The companies execute " on right into line " in succession and as prescribed for the individual company.

At the bt. c.'s **march,** following the preparatory command given above, the first or leading company executes " on right into line " as prescribed for the individual company, each squad of the company executing right turn in succession and the company advancing with squads " in echelon." Each following company continues forward in column of squads until its first squad uncovers the left of the preceding company, when, at the command of its c. c., it executes " on right into line " as was done by the leading company.

(Bt. c.) — **Battalion, Halt!**

This command may be given at any time after the leading squad of the first company has completed the turn and is advancing in the new direction. At the **halt,** this leading squad halts and comes automatically to right dress. Other squads and companies continue to advance, carrying out the move, the squads halting and dressing right as they arrive on the line. When a complete company is on the line, its alignment is verified or corrected by the c. c., who then commands " **front.**"

RULES FOR REPETITION OF COMMANDS BY COMPANY AND SECTION LEADERS IN BATTALION FORMATION

Company Commanders repeat every preparatory command of the bt. c. for moves that are to be immediately executed by their company. **This rule holds particularly for all simultaneous evolutions** — squads right; companies, right by squads, etc.

Chiefs of Sections repeat the preparatory command when the section is the unit and the move is to be executed immediately by the section. The c. cs. in this case keep quiet, the cs. o. s. being the only ones to repeat the command. — **Sections left front into line, double time**; **Sections, column right, etc.**

The **command of execution** is always given by the bt. c. and is never repeated.

In **successive evolutions,** the c. c. of the leading company gives the preparatory command to his company if it so happens that his preparatory command varies from that given by the bt. c. — **(bt. c.)** — **Column right** (**c. c. 1 Co.**) — **Right turn.** Following companies make the turn on the commands of their c. cs., who give both preparatory and execution commands. The rules set forth here apply alike to c. cs. and cs. o. s.

In **executing the manual of arms** all commands are given by the bt. c. No repetition is necessary by c. cs., either of preparatory or execution commands.

In successive evolutions, such as **column of squads, first company, squads right,** the leader of the first company or section does not repeat the preparatory command. Succeeding leaders give both commands.

C. cs. may prefix the number or particular designation of their companies to their commands, if desired, such as: first company, halt, etc. This, however, is unnecessary. The shorter the command, the better.

In giving commands they should be brief and sharp. Nothing sounds worse than a babble of commands following a command by the bt. c., most of them from people who are

supposed to keep quiet. There should be no noise or useless commands or repetition of them. Commands are restricted to such as are absolutely necessary to give the units a clear idea of what to execute.

FORMATIONS IN MASS

This consists as a rule in closing the companies in toward each other in column, forming what is termed **close column.**

The distance between companies is eight paces.

C. cs. are two paces in front of their companies; file-closers close in to one pace in rear of rear rank.

Close line is the same as "line of companies", except that there are only seven pace intervals between the flanks of the companies.

To Form Close Column:

(**Bt. c.**) — **Close on first company, March!**

At the **march,** the first company stands fast if halted and if marching, halts. Following companies close in to eight pace intervals, halt, and dress companies toward point of rest.

GENERAL

"ROUTE STEP" AND "MARCH AT EASE" IN BATTALION.

(**Bt. c.**) — **Route Step, March!** or **At ease, March!**

Executed the same and subject to the same rules as outlined for the company.

ASSEMBLY.

When the companies are separated and it is desired to reform them in battalion front, cause the bugler to sound "Assembly", or, if companies are not too widely separated, command, **Assemble, March!**

Companies assemble on the bt. c. at a point designated by the bt. adj. The assembly unless otherwise indicated by the bt. adj. is in battalion front.

GENERAL RULES FOR FACINGS, MANUAL OF ARMS, ETC.

The battalion executes facings,, steps, and executes the manual of arms, etc., according to the rules given for the recruit, squad, and company, and at the command of the battalion commander.

TO DISMISS THE BATTALION.

(Bt. c.) — **Dismiss Your Companies.**

Each company commander takes charge, marches his company off the drill or parade ground, and dismisses it according to rules given for the company.

REVIEWS AND PARADES

For all parades and reviews, the colors and color guard must be present.

The **color guard** takes position on the left of the color company after the battalion has been formed.

The **color company is usually the center company**. In a battalion of four companies, the second company is the color company. This brings the colors in the center of the battalion line between the second and third companies.

Before the color guard takes post in line, or as it marches on the field, it is drawn up in line facing the color company. The c. c. causes his company to **present, arms**! to the colors. The salute is returned by the color guard and they march to their position.

Marching in column at a parade or review, the bt. c. and his staff take post at the head of the column, 20 paces in front of the leading company. The bt. adj. takes post on the right of the bt. c.'s staff.

The band precedes the bt. c. and staff at the head of the column by 10 paces. While a battalion is passing in review before high ranking officers, dignitaries, etc., the reviewing stand is usually on the right flank of the column. The band when opposite the reviewing stand turns out of the column to the left, and takes post opposite and facing the reviewing

party. It plays the battalion by and then falls in column in the rear of the last company as it passes by.

As each company passes the reviewing stand it executes **eyes, right!** at the command of the c. c. when six paces from the reviewing stand. The company commander comes to **present** with his sword, or renders hand salute if without side arms. Each man keeps head and eyes to right until command **front** by the c. c. when six paces past the reviewing party.

The bt. c. and staff turn out of column to the right and take post on the right of the reviewing party as the battalion passes by. As the last company passes, the bt. c. and staff fall into the rear of the column.

There are any number of other rules laid down for inspections, reviews, and parades. Only the most essential points have been briefly mentioned. Reference is made to the detailed instructions on the subject to be found in the "**Landing Force and Small Arms Instructions**" issued by the **Navy Department.**

The above applies to a review of the "battalion" only.

REGIMENT

A **regiment normally consists of four battalions**, although it can consist of two or more. The regiment holds the same relation to a battalion as the battalion does to a company. A regiment is maneuvered along the lines laid down for the battalion.

BRIGADE

A **brigade consists of two or more regiments.**

Table of s 3,000, 6,000 and 9,000 Yards, with
pact—Blunt Nose Cap.

Gun.	Yards.	At 6,000 Yards.		At 9,000 Yards.	
	Penetration.	Remaining velocity.	Penetration.	Remaining velocity.	Penetration.
	Inches.	*Ft. Sec.*	*Inches.*	*Ft. Sec.*	*Inches.*
3-inch R. F.	1.2	848	0.8	...	...
3-inch S. A.	1.2	848	0.8	...	...
4-inch R. F.	1.7	897	1.2	...	...
4-inch R. F.	2.2	979	1.4	858	1.2
4-inch R. F.	2.6	1,033	1.5	878	1.2
5-inch R. F.	2.6	934	1.7	829	1.4
5-inch B. L.	3.5	1,102	2.0	928	1.6
5-inch B. L.	3.2	1,057	1.7	877	1.4
5-inch R. F.	3.4	1,091	1.8	896	1.4
6-inch R. F.	3.2	1,009	2.3	909	2.0
6-inch R. F.	3.6	1,068	2.4	934	2.1
6-inch R. F.	3.8	1,086	2.5	948	2.1
6-inch B. L.	4.7	1,207	2.9	996	2.2
6-inch B. L.	5.2	1,297	3.2	1,026	2.3
7-inch B. L.	6.4	1,382	4.2	1,083	3.0
8-inch B. L.	6.0	1,206	4.2	1,040	3.6
8-inch B. L.	7.5	1,428	5.3	1,141	4.0
8-inch B. L.	8.6	1,589	6.1	1,227	4.4
10-inch B.	8.0	1,274	6.1	1,108	5.0
10-inch B.	11.9	1,747	9.0	1,406	6.9
12-inch B.	11.2	1,438	8.8	1,219	7.2
12-inch B.	13.3	1,649	10.5	1,376	8.3
12-inch B.	14.8	1,801	11.7	1,500	9.3
12-inch B.	15.5	1,877	12.3	1,561	9.8
12-inch B.	16.6	1,991	13.3	1,653	10.6
12-inch B.	17.5	2,071	13.9	1,719	11.0
13-inch B.	12.0	1,414	9.7	1,221	8.1

Table of … 3,000, 6,000 and 9,000 Yards, with …act—Blunt Nose Cap.

Gun.	… Yards.	At 9,000 Yards.		At 9,000 Yards.	
	Penetration.	Remaining velocity.	Penetration.	Remaining velocity.	Penetration.
	Inches.	*Ft. Sec.*	*Inches.*	*Ft. Sec.*	*Inches.*
3-inch R. F.	1.2	848	0.8	...	...
3-inch S. A.	1.2	848	0.8	...	...
4-inch R. F.	1.7	897	1.2	...	...
4-inch R. F.	2.2	979	1.4	858	1.2
4-inch R. F.	2.6	1,083	1.5	878	1.2
5-inch R. F.	2.6	934	1.7	829	1.4
5-inch B. L.	3.5	1,102	2.0	928	1.6
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6-inch R. F.	3.2	1,009	2.3	909	2.0
6-inch R. F.	3.6	1,058	2.4	934	2.1
6-inch R. F.	3.8	1,086	2.5	948	2.1
6-inch B. L.	4.7	1,207	2.9	996	2.2
6-inch B. L.	5.2	1,297	3.2	1,026	2.3
7-inch B. L.	6.4	1,332	4.2	1,082	3.0
8-inch B. L.	6.0	1,306	4.2	1,040	3.6
8-inch B. L.	7.5	1,428	5.3	1,141	4.0
8-inch B. L.	8.6	1,589	6.1	1,227	4.4
10-inch B.	8.0	1,274	6.1	1,108	5.0
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